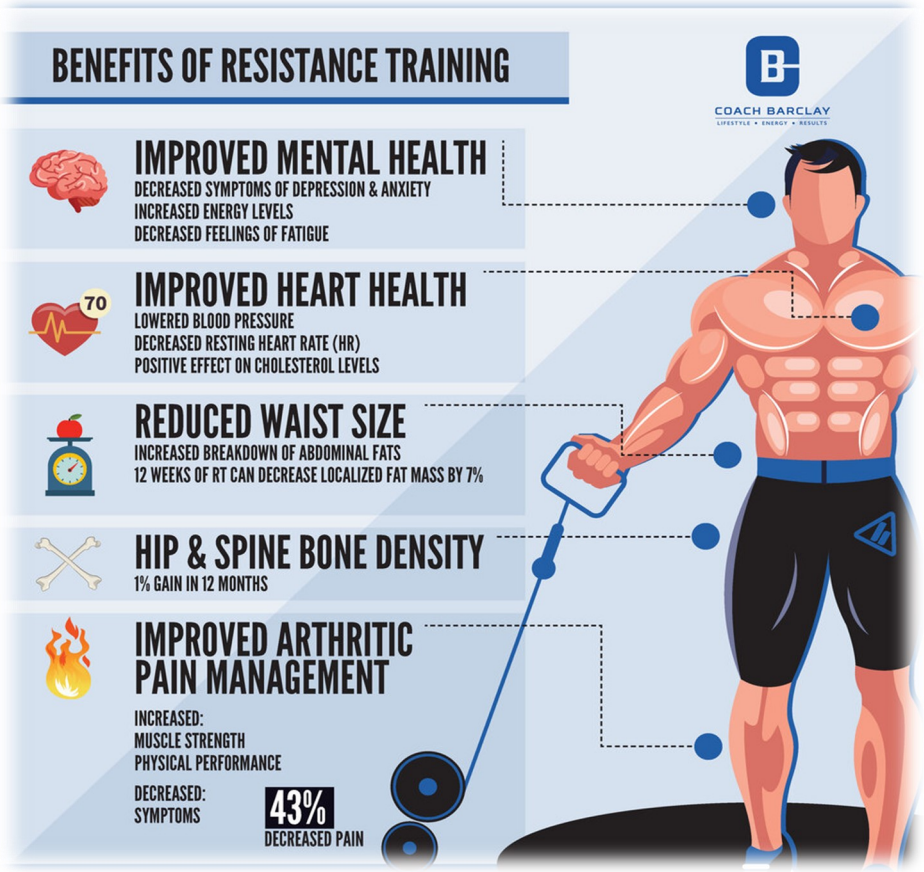
Departmental Publication of PhD Thesis

EFFECT OF RESISTANCE TRAINING AND DE-TRAINING ON SELECTED PHYSICAL FITNESS PHYSIOLOGICAL AND BODY COMPOSITION PARAMETERS OF INTER COLLEGIATE KABADDI PLAYERS

Dr P Muthukumar



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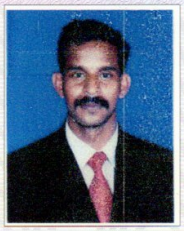

உடற்கல்வியியற் புலம்

FACULTY OF PHYSICAL EDUCATION

மனோன்மணியம் சுந்தரனார் பல்கலைக்கழக ஆட்சிக்குழு

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உடற்கல்வியியல் பாடப்பிரிவில்

அறிஞர் பட்டம் பெறுவதற்குத் தகுதியுடையவர் என முறையாக அமைக்கப்பெற்ற தேர்வினோர் சான்றளித்தவாறு பிப்ரவரி 2019 ஆம் ஆண்டில் இப் பட்டப்பேற்றுக்கு உரியவர் ஆகின்றார் என இதன்வழி அறிவிக்கின்றது.

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Dr P Muthukumar

Book Version of the PhD Thesis
submitted to
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EFFECT OF RESISTANCE TRAINING AND DE-TRAINING ON SELECTED PHYSICAL FITNESS PHYSIOLOGICAL AND BODY COMPOSITION PARAMETERS OF INTER COLLEGIATE KABADDI PLAYERS

A THESIS

Submitted by

P. MUTHUKUMAR

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EFFECT OF RESISTANCE TRAINING AND DE-TRAINING ON SELECTED PHYSICAL FITNESS PHYSIOLOGICAL AND BODY COMPOSITION PARAMETERS OF INTER COLLEGIATE KABADDI PLAYERS

ABSTRACT

The purpose of the study was to find out the effect of resistance training and detraining on physical fitness, physiological parameters and body composition variables of inter-collegiate kabaddi players. To achieve the purpose of this study, thirty male inter-collegiate kabaddi players volunteered to participate in the study. The selected participants were studying in various arts and science colleges affiliated to Manonmanium Sundaranar University, from kanyakumari district, India during the academic year 2016-2017. Their age ranged from 18 years to 22 years. They were randomly divided into two groups and each group consisted of fifteen participants. Group – I performed resistance training and group – II acted as control who did not participate in any specific training programmes. The subjects were tested on the following variables such as, muscular strength, explosive power, resting heart rate, Vo_2 max, percent body fat and body mass index. The test conducted for two groups prior to and post experimentation and detraining (three cessation) once in ten days. The selected dependent variable muscular strength was measured by 1 RM bench press, explosive power was measured by standing broad jump, resting heart rate was assessed by digital blood pressure monitor, Vo_2 max was assessed by 1 mile run test, percent body fat was measured by skin fold calibre, body mass index was calculated by weight/height meter^2. The data collected from the two groups prior to and post experimentation were statistically analyzed by applying the analysis of covariance (ANCOVA). The data collected from the two groups on prior and post experimentation and detraining (three cessation) were statistically analysed by using two way (2 x 4) factorial ANOVA with last factor repeated measures. If the obtained 'F' ratio for interaction effect was found to be significant, the simple effect test was used as a follow up test. Since, two groups and four different stages of test were compared, when the obtained 'F' ratio value in the simple effect test was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases statistical significance was fixed at .05 levels. The result of the study indicates that resistance training improved muscular strength, explosive power, maximum oxygen consumption and decreased resting heart rate, body mass index, percent body fat, to a significant level. However, during the detraining period the improved performance was started declining towards the baseline.

KEY WORDS: *Resistance training, Detraining, Physical fitness, Physiological parameters, Body composition and Kabaddi players*

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Chapter I

INTRODUCTION

In India kabaddi is major sports, which is played all over the India. This game is also getting a good status in Asian sports. This game is classified as a team game. Kabbadi is basically an Indian game, which requires both skill and power. Kabaddi combines the characteristics of wrestling and rugby. Kabaddi is played in more than sixty five countries especially Asian countries. With the introduction of the game in the Asian and other international competitions, the popularity has grown.

Many team sports include complex human movement, which can be observed at different levels of detail. This is especially true for team sports kabaddi. Kabaddi is one of the most popular team based sports and has been played by both men and women throughout the world. Kabaddi is basically an outdoor team game, played in the tropical countries of Asia. The excitement and thrill provided by the game has made it very popular and Kabaddi is rightly called the ‘Game of the masses’, since spectators totally involve themselves and give the players a great deal of encouragement.

In modern sports, successful performance is determined by number of factors. For optimum performance at elite level, variety of areas must be addressed. Further, Kabaddi is the game where size, shape and body composition play an important part in providing distinct advantage for specific playing positions. These include the skill level, flexibility, endurance and most importantly the specific use of anthropometric measurements which plays a

vital role in complex team based games. Since success in the game depends among other things, on how the individual characteristics of some players fit into the whole, thus creating a coherent team. Kabaddi is one of the complex technical team based game and performance differences between players of varying ability levels are different.

The game calls for agility, good lung capacity, muscular coordinates, presence of mind and quick responses. For a single player to take on seven opponents is no mean task, requires dare as well as an ability to concentrate and anticipate the opponents moves. There is a gradual but marked change in the style of the game during the past fifty years. What was once considered a game of brawn is not so now. The introduction of more techniques to the game has made it relatively easier for a player with more skill than weight to score points against better-built opponents.

Kabaddi is one of the popular team sports which require a high standard of preparation in order to complete 40 minutes of competitive play and to achieve success. In this game movement patterns are characterised as intermittent and change continuously in response to different offensive and defensive situations. Anthropometric factors and morphological characteristics can influence the effectiveness of such responses, as has been observed in other sports. Therefore, anthropometric profiles may contribute to understanding the suitability of players for the sport of Kabaddi, particularly elite level.

The knowledge of the physical characteristics of Kabaddi players could provide insight into those individual factors which influence the players'

performance in the game. Anthropometric characteristics are very relevant for Kabaddi players because the game of Kabaddi entails physical contact in which specific physiques with a high level of strength and power may provide an advantage. The Anthropometric characteristics of Kabaddi players are considered in the choice of players to implement the game plan.

1.1: Predominant Qualities of Kabaddi Players

Sports science plays a critical role in Kabaddi performance. The game Kabaddi is a team based sport and it demands number of external and internal factors like anthropometrical, physical, physiological and psychological characteristics to play the game at elite level. The basic skills like holding, riding, blocking, and breath holding are highly needed. It is true that these skills are basic abilities for all Kabaddi players, but the performance potential depends on specific variables. The coaches and trainees may not be able to determine them by their subjective observations of performances alone.

A scientific analysis of the player's performance with respect to their skills might help in a much more positive way. This will enable not only the right type of selection based on scientific data but also help in maximizing the player's potentials by regrouping and synchronizing the team talents that are available. Hence, the selection, the training, the performance and monitoring of game strategies can be updated by a study on scientific training and performance of the players. Though the players of the team are drawn from a particular age group, as in the case of University Teams, and their general skills measure to a standard level which has ensured their selection in their respective

University Teams, their performance levels may vary, deciding the success or failure of their teams. In sports, successful performance in competition depends substantially on the physical characteristics, body composition, muscular performance, neuromuscular capability and mental ability of the players.

Previous reports have shown that body structure and morphological characteristics are important determinants of performance in many sports and certain physical impressions such as body composition (body fat, body mass, muscle mass) and physique (somato type) can significantly influence athletic performance (Carter, 1970 & Duquet and Carter, 2001). In high performance sport, a great importance is given to the physical condition. It is in fact the preoccupation for the adaptation of the sports man's body to growing physical and mental efforts, to which all the parts of the human body participate. The contemporary Kabaddi game, characterized by high intensity motor activities, places upon players a wide spectrum of requirements on all their capabilities. One can hardly single out any ability or a characteristic which is not engaged in the performance of Kabaddi players. Kabaddi is a endurance game. Without endurance the player cannot perform well, in the same time the player's need all the characteristics i.e. speed, agility, flexibility, endurance etcetera. Nowadays most of the players having good height can perform well in the game situation. Without physical characteristics players cannot achieve the aim of the game, so physical characteristics is very essential for the better performance of Kabaddi.

Basic and specific motor abilities and cardio-respiratory capacities, such as explosive strength, required at the centre line. As well as agility and speed which are indispensable for the efficient solving of game situations. A high level of aerobic capacity ensures the slower onset of fatigue and a fast recovery, whereas anaerobic capacity is responsible for endurance in high intensity repetitive activities.

Team Kabaddi is a complex intermittent game, which requires players to have well developed aerobic and anaerobic capacities. Motor ability, sprinting, jumping, flexibility and throwing velocity represent physical activities that are considered as important aspects of the game and contribute to the high performance of the team. Successful performance requires explosive power of the legs and arms, sprint velocity. (Sibila, 1997).

The specific characteristic of Kabaddi demands from players an effective participation in activities that need a good aerobic and anaerobic response. However, some authors report that Kabaddi is a sport that demands predominantly the motor capacities that depend on the anaerobic metabolism. Thus, it seems reasonable to affirm that the motor capacities strength & velocity and their ways of manifestation are crucial, since the technical and tactical capacities can be consistently superior when the Kabaddi players present high levels of adaptation of the anaerobic metabolism.

1.2: Resistance Training

Resistance training is fast becoming the most popular exercise in the world today. For centuries, resistance training was primarily used only for the

strengthening and conditioning of certain athletes. Even in the sports world, many players and coaches did not emphasize the importance of resistance training if their particular sport did not require them to have high levels of muscular strength in order to be competitive. However, in recent years the amount of information and research on resistance training has exploded. Players of all types, from the professional to the weekend enthusiast now understand the potential benefits of partaking in resistance training program. The amount and form of resistance used as well as the frequency of resistance exercises are determined by specific program goals.

Resistance training programmes should be tailored to meet the needs and goals of the players and should incorporate a variety of exercises performed at a sufficient intensity to enhance the development and maintenance of muscular strength and game performance. Resistance training can result in superior gains in strength and power performance. A number of training programmes have been successful in bridging the gap between the physical fitness and performance improvement. From the availability of the literatures it was observed that the resistance training programme are improved the physical fitness, physiological and body composition of athletes and players. When properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being, including increased bone, muscle, tendon and ligament strength and toughness, improved joint function, reduced potential for injury, increased

bone density, a temporary increase in metabolism and improved cardiac function.

Resistance training is the use of resistance to muscular contraction to build the strength, anaerobic endurance, and size of skeletal muscles. There are many different methods of resistance training, the most common being the use of gravity or elastic/hydraulic forces to oppose muscle contraction. In sports movement, strength always appears in some combination with the duration and speed of movement i.e., in combination with endurance and speed abilities. In each sports movement strength appears in a different form.

Strength should not be considered a product of only muscular contractions. It is a product of voluntary muscle contractions caused by the neuro-muscular system. All movements in sports are caused by muscle contractions therefore strength training assumes high importance for achieving good performance in all sports. The roll of strength training for general health, good posture and for prevention of injuries is usually overlooked which in the long run can prove harmful.

Resistance training, weight training, and progressive resistance exercise are just a few terms used interchangeably to describe using resisted movements to increase muscle mass, strength, or power. Both male and female players now generally undertake extensive resistance training programs under the direction of their team coach or specialist strength and conditioning coach for a variety of reasons including injury prevention and improving power output. Resistance training has been shown to improve the lactate threshold (Marcinik

et al., 1991). Resistance training has improved the anaerobic threshold in cross-country skiers (Hoff et al., 1999). Resistance training can also improve a wide range of sports and sporting activities including throwing.

Improvements in muscular strength, as measured by the force produced during a maximal voluntary contraction, occur as a result of an increase in muscle cross sectional area and the ability to effectively activate motor units (Sale, 1992). The increase in cross-sectional area of muscle is considered to occur as a result of protein synthesis, primarily actin and myosin in the myofilaments, which produces a greater number of contractile units (Goldspink, 1992). Enhanced motor unit activation results from a greater number of fibers being recruited, increased firing frequency, decreased co-contraction of antagonists, better synchronization of motor unit activation and inhibition of reflexive mechanisms such as the Golgi tendon organ that normally govern the amount of force that can be generated (Sale, 1992; Wilson, 1994).

1.3: Factors Influencing Resistance Training

There are many variables which describe a resistance training program, in which the principle variables are training intensity and volume. Specifically by manipulating training intensity, training volume and other variables, the wholesome development of an individual can be enhanced. Training intensity and training volume plays a vital role while designing a resistance training program.

The correlation between training volume and intensity has its own merits and demerits. High intensity combined with low volume training is acceptable, only for a stimulated period of time though it increases muscular strength under resistance training, whereas aerobic capacity does not improve. It was vice-versa under low intensity and high volume training. The volume of training to be imposed has its own limitations over training which can lead to stress, resulting in utter failure to achieve the goal. Therefore, efforts are made by physiologists to determine the maximal and minimal stimuli needed for cardiovascular activity and improvement of muscles in human being.

1.3.1: Training Intensity

Intensity is an important component of training. It is the qualitative work that an athlete performs in a given time. More the work performed by an athlete per unit of time, higher will be the intensity. Intensity is a function of the strength of the nerve impulses that the athlete employs in training. Intensity, along with the volume and density, is one of the most important components of training. It refers to the qualitative component of work performed in a given period in time. In strength training, intensity is expressed as a percentage of load or one repetition maximum (1RM) (Fox & Mathews, 1981).

It represents the degree of effort made by the sportsperson while performing an exercise. The degree of effort is always considered in relation to time and is equated with the amount of force or energy spent in relation to time. It is divided into intensity of stimulus (load intensity) and density of stimulus (load density) (Uppal, 2009).

1.3.2: Training Volume

Volume is a prime component of training and is the quantitative prerequisite for high technical, tactical and physical achievements. The volume of training, sometimes inaccurately called as the duration of training includes the following integral parts namely the time or duration of training, distance covered or weight lifted per unit of time and the repetitions of an exercise or technical element an athlete performs in a given time.

Volume implies the total quantity of activity performed in training. Volume also refers to the sum of work performed during a training lesson or phase. When you refer to the volume of a training phase, it means that it is the sum of the repetitions performed during each training session multiplied by the resistance used (Kraemer et al., 2002). Throughout the resistance training program, volume and intensity must be systematically increased (progression principle) to avoid plateaus and to ensure continued strength improvements. The training volume may be altered by changing the number of exercises performed for each session, the number of repetitions performed for each set, or the number of sets performed for each exercise. Several models of periodized training can be used to systematically vary the volume and intensity.

1.3.3: Set

Traditionally, a set refers to the number of sets performed for a specific muscle group which is a better indicator of training stress than sets per exercise. The optimal number of sets for improving muscular strength is controversial and depends on the trainee's goal, one to two sets for children and

older adults and one to three sets for novice and intermediate lifters are recommended (Kraemer et al., 2002). Some studies suggest that single sets (one set per exercise) are just as effective as multiple sets (two to three sets per exercise) for increasing the strength of untrained and recreational lifters during the first three to four months of resistance training (Feigenbaum and Pollock, 1999). A major advantage of single-set programs is that they require much less time for a training session than do multiple-set programs (twenty versus fifty minutes), potentially increasing the trainee's compliance. The ACSM (2006) recommends prescribing one set performed to the point of fatigue for each exercise.

However, the results of a recent meta-analysis of one forty strength training studies do not support prescribing single-set programs to develop the strength of untrained and trained recreational lifters (Rhea et al., 2003). Using this definition of sets, it is reported that an average of four sets during each training session optimizes strength development in untrained and trained lifters. For single-set programs, the authors suggest prescribing multiple exercises for a specific muscle group in order to reach the goal of four sets.

One can use either a single set or multiple sets of exercise. For multiple sets, one may choose to have the trainee consecutively perform a designated number of sets (usually three or more) at a constant intensity e.g., 10-RM for each exercise. Alternatively, you may have your trainee perform one set of three different exercises for the same muscle group. For example, instead of three consecutive sets of barbell curls for the elbow flexors, coach may

prescribe one set of incline dumbbell curls, one set hammer curls, and one set of barbell curls. This adds variety to the program and changes the training stimulus since different muscles or parts of a muscle are used to perform each of these exercises.

A trainee performing multiple sets of a given exercise may choose to lift the same weight for each set or to vary the intensity of each set by lifting progressively heavier (light to heavy sets) or lighter (heavy to light sets) weights. Pyramiding is a light to heavy system in which the trainee performs as many as six sets of each exercise. In the first set, the trainee lifts a relatively lighter weight for ten to twenty repetitions (10 to 12 RM). In subsequent sets the individual lifts progressively heavier weights (i.e., 8-RM, 6-RM, and 4-RM). Since this involves such a large volume of work, trainer should prescribe the pyramid system for experienced weightlifters only. Bodybuilders commonly use this system to develop muscle size.

Multiple sets using periodization are recommended for serious athletes, power lifters and bodybuilders engaged in advanced strength training and hypertrophy programs (Kraemer et al., 2002). To optimize the strength gains of collegiate and professional athletes, an average of 8 sets per muscle group is recommended (Peterson et al., 2004).

1.3.4: Frequency

Muscular fitness may improve from exercising just one day per week, especially in trainees with below-average muscular fitness. Recent research, however, suggests that the optimal frequency of strength training for untrained

individuals is three days per week. For healthy populations, the ACSM (2006) recommends two to three non-consecutive days per week. For advanced lifters, four to six training sessions are recommended (Kraemer et al., 2002).

Traditionally for advanced resistance training programs, experts have recommended resistance training three times per week on alternate days (e.g., M-W-F) to allow time for the muscles to recover. For individuals who want resistance training four to six days per week, a split routine was prescribed. With a split routine different muscle groups are targeted on consecutive days, thereby allowing at least one day of recovery for each muscle group. For example, a bodybuilder may exercise the chest and shoulders on Monday and Thursday, the hips and legs on Tuesday and Friday, and the back and arms on Wednesday and Saturday.

To optimize the strength gains of trained recreational lifters and competitive athletes, each muscle group should be exercised twice a week (Peterson et al., 2004). Advanced lifters and competitive athletes who train four to six days per week can accomplish this goal by using split routine. A rest of forty eight hours between workouts should be allowed for muscles to recuperate and to prevent injury from overtraining.

1.4: Designing Resistance Training Program

The training program needs to be individualized. By varying the combination of intensity, duration and frequency of exercise, one can develop programs that meet the unique goals and needs of each trainee. Proper guidelines and recommendations for resistance training programs, as well as

specific recommendations and precautions are to be followed when developing resistance training programs. ACSM (2006) has summarized guidelines for the resistance training of healthy populations

During the first eight weeks of training, use minimal resistance for all exercises. Instruct about proper weightlifting and breathing techniques. Trained exercise leaders who have experience should closely supervise and monitor the trainee's weightlifting techniques and resistance training program during the first few exercise sessions. Prescribe multi-joint, rather than single-joint, exercises. Use exercise machines to stabilize body position and control the range of joint motion. Avoid using free weights at initial stages. Each exercise session should be approximately twenty to thirty minutes and should never exceed sixty minutes. Prescribe one set of ten to fifteen repetitions for eight to ten different exercises for the major muscle groups. Allow at least forty eight hours of rest between the exercise workouts. Discourage trainees with joint pain or inflammation. When trainees are returning to resistance training following a layoff of more than three weeks, they should start with a low resistance that is less than fifty percent of the weight they were lifting prior to the lay off.

The ACSM (2006) recommends moderate intensity (RPE=23-13) exercise to improve the muscular fitness of older adults; prescribe one set of ten to fifteen repetitions for eight to ten different exercises. Previous study noted long term (6 Months) improvements in the strength and muscular endurance of older adults (60-83 years) who participated in either a low

intensity (1 set at 50% 1-RM) or a high intensity (1 set at 80% 1-RM) resistance training program three days per week likewise, another study reported that isometric and dynamic muscle strength gains are similar for older adults (>60years) engaging in either a non periodized, high-intensity program (2 sets at 80% 1-RM, 3 days per weeks) or an undulating periodized (UP) program varying training volume each day (2 sets at 50%, 65%, or 80% 1-RM, 3 days per week). Some evidence suggests that training for one, two or three days a week at eighty percent of one repetition maximum produces similar strength gains in older (65-79years) men and women (Taaffe et al., 1999).

The optimal training stimulus for developing muscular strength or endurance is controversial. Some research supports the conventional prescription of high intensity-low repetition resistance exercise for strength development and low intensity-high repetition exercise for muscular endurance (Kraemer et al., 2004). Contrary to this traditional approach, the ACSM (2006) supports the position that muscular strength and endurance develop simultaneously over a wide range of repetitions (3to20) provided that the resistance exercise (whether 3-6, 9-12, or 12-15 repetitions) is performed at a high intensity (i.e., to the point of muscular fatigue or failure). To develop the strength and muscular endurance of healthy individuals, the ACSM (2006) recommends eight to twelve repetitions performed at high intensity.

The mean optimal intensity for developing strength ranges between sixty percentages and sixty percentage of one repetition maximum. At these intensities, most individuals are able to perform one to twelve repetitions (1-

RM to 12-RM). The trainee's experience with resistance training dictates the optimal intensity for developing strength. Generally, one should prescribe intensities of sixty to seventy percentages of one repetition maximum for novice lifters, and seventy to eighty percentages of one repetition maximum for advanced lifters. Recent meta-analyses support these recommendations. Rhea et al., (2003) reported that the optimal intensity for strength gains in untrained (<1 years) lifters differs (60% 1-RM and 80% 1-RM, respectively) and for competitive athletes (college and professional), the optimal training intensity is eighty five percentage of one repetition maximum (Peterson, Rhea, and Alvar 2004) keeping in mind that these intensities are averages. Throughout the strength training program, intensity needs to be varied for continued improvement.

Although this training stimulus may be sufficient for beginner and novice lifters, experts recommend that, resistance training programs be tailored to the specific goals of intermediate and advanced lifters (Kraemer & Ratamess, 2004). It is possible to design programs to optimize the development of muscle strength, size (hypertrophy), endurance or power by varying the intensity repetitions, sets, and frequency of training.

1.5: Benefits of Resistance Training

The impact of resistance training has been widely accepted by medical and fitness organizations in the global scenario. It has multifaceted advantages *viz.,* to strengthen bones, improving or stabilizing weight, changing the psychosocial wellbeing and in reducing risk of cardiovascular related problems.

Resistance training plays a pivotal role in improving the general health and fitness of people; hence more focus has to be given in the near future. Resistance training has become popular in recent times especially in improving the health of population.

Resistance training as an exercise programme where free or stationary weights are used for the purpose of increasing muscular strength, muscular endurance and power, through which skills can be improved (Moran & Mcglynn, 1990). When properly performed, resistance training can provide significant functional benefits and improvement in overall health and well-being, including increased bone, muscle, tendon and ligament strength and toughness, improved joint function, reduced potential for injury, increased bone density, a temporary increase in metabolism, improved cardiac function, and elevated HDL (*good*) cholesterol.

The benefits of resistance training include greater muscular strength, improved muscle tone and appearance, increased endurance, enhanced bone density, and improved cardiovascular fitness (Abernethy, 1997). Resistance training programme helps in loosing fat weight and gaining fat free weight due to muscle hypertrophy. Resistance training does not mean one will lose flexibility or become muscle bound. A study on Olympic athletes has shown that only the gymnasts have better flexibility than the weight lifters. Weight training does not slow down muscular movement. It has also been established that increase in muscular speed (*Explosive Power*) accompanies an increase in muscular strength (Riley, 1982).

Though resistance training can stimulate the cardiovascular system, many exercise physiologists, based on their observation of maximal oxygen uptake, argue that aerobics training is a better cardiovascular stimulus. Central catheter monitoring during resistance training reveals increased cardiac output, suggesting that resistance training shows potential for cardiovascular exercise.

The benefits of resistance training include increased muscle, tendon and ligament strength, bone density, flexibility, tone, metabolic rate and postural support. Resistance training provides a foundation for overall fitness plan which gives the ability to build muscle mass for improved performance. The benefits of weight training include greater muscular strength, improved muscle tone and appearance, increased endurance and enhanced bone density.

Resistance training has been recommended by national health organizations to be included in fitness programmes which include aerobic and flexibility exercise. Resistance training has numerous uses; it increases basal metabolic rate, increase muscle and connective tissue cross sectional area reduced cholesterol, improves blood lipid profile, decreases blood pressure, glucose tolerance, improves insulin sensitivity, improves functional capacity and relieves low back pain. The key element to resistance training lies in supervision by qualified professional and the proper usage of the program variables (Kraemer et al., 2002).

In addition to benefit in muscle tone and shape, strength exercises build stronger and healthier bones. The 'Journal of the American Medical Association' recently published the result of a 16 weeks study on resistance

training for men and women conducted at the Oregon Health sciences university. The findings were more impressive than that had been suspected and they discovered that, for both men and women regular resistance training of sufficient intensity generally led to modest improvements in blood cholesterol profiles and increased lean body mass and exercise ability (improving a dramatic 100 percent for both men and women), even though the participants did not change daily habits during the study.

1.6: Detraining

Detraining refers to the cessation of regular physical training. The effects of stopping training are quite minor compared with those from immobilization. In general, greater the gains during training, the greater the losses during detraining, simply because the well-trained person has more to lose than the untrained person. Detraining causes muscle atrophy, which is accompanied by losses in muscular strength and power. However muscles require only minimal stimulation to retain these qualities during the periods of reduced activity (Wilmore & Costill, 1994).

Detraining often referred to as ‘reversibility’ reflects the fact that if a training stimulus is insufficient, or removed entirely, then the aspect of physiological conditioning to which it relates begins to decline. In other words, the individual begins to lose ‘fitness’ or ‘level of conditioning’.

The coaches, physical fitness experts and athletes are focusing their attention on the actual process of physical training and the physiological adaptations which allow the athlete to improve his general and specific

physical fitness for the enhancement of athletic ability and performance in competitive situation. The researchers and sports scientists have taken enough pains to know the effects of physical training on specific components of physical. An area that is equally important but that has been given considerably less attention by both the athletes and the coaches and has practically been ignored by the research scholars in the exercise and sports sciences is the area of detraining and off season conditioning programme. In general, the removal of a training stimulus produces a significant loss in conditioning after two to six weeks. So the coaches, physical fitness experts and athletes might be focus on detraining.

1.7: Physical Fitness Requirements of Kabaddi Players

Physical Fitness is the capacity to carry out reasonably well various forms of physical activities without being unduly tired and includes qualities important to the individuals' health and well being. Physical fitness is an ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet any unforeseen emergencies.

Physical fitness is the basic requirement for most of the tasks to be under taken by an individual in his daily life. Physical fitness is one's richest possession; it cannot be purchased but only obtained through regular routines of physical exercises. A close relationship exists between physical fitness and sports performance. In case the standard of games and sports in the country is to be improved, adequate stress have to be given for enhancing the physical

fitness status of sports persons. Regular participation on training schedule improves all the important physical, physiological and psychological fitness components.

It is the ability of an athlete to perform successfully at their sport. The components of physical fitness are speed, strength, endurance, agility, flexibility, balance, co-ordination, power and reaction time. From the above mention components the investigator selected the muscular strength and explosive power as dependent variables.

In performance and high performance sport, a great importance is given to the physical condition. It is in fact the preoccupation for the adaptation of the sportsman's body to growing physical and mental efforts, to which all the parts of the human body participate. The contemporary kabaddi game, characterized by high intensity motor activities, places upon players a wide spectrum of requirements on all their capabilities. One can hardly single out any ability or a characteristic which is not engaged in the performance of kabaddi players. Basic and specific motor abilities and cardio-respiratory capacities, such as explosive strength, required at the centre line. As well as agility and speed which are indispensable for the efficient solving of game situations. A high level of aerobic capacity ensures the slower onset of fatigue and a fast recovery, whereas anaerobic capacity is responsible for endurance in high intensity repetitive activities.

Team kabaddi is a complex intermittent game, which requires players to have well developed aerobic and anaerobic capacities. Motor ability, sprinting,

jumping, flexibility and throwing velocity represent physical activities that are considered as important aspects of the game and contribute to the high performance of the team. Successful performance requires explosive power of the legs and arms, sprint velocity. The specific characteristic of kabaddi demands from players an effective participation in activities that need a good aerobic and anaerobic response. However, some authors reported that kabaddi is a sport that demands predominantly the motor capacities that depend on the anaerobic metabolism. Thus, it seems reasonable to affirm that the motor capacities strength & velocity and their ways of manifestation are crucial, since the technical and tactical capacities can be consistently superior when the kabaddi players present high levels of adaptation of the anaerobic metabolism kabaddi is an endurance game. Without endurance the player cannot perform well, in the same time the player's need all the characteristics i.e. speed, agility, flexibility etcetera.

1.8: Physiological Components

Physiological fitness is the capability of the heart, blood vessels, lungs and muscles to function at optimal efficiency, which means the level of health needed for the enthusiastic and pleasurable participation in daily task and recreation activities.

It is a physiological fact that the human organism needs a stimulating exercise. When the whole body is subjected to regular muscular activity, requiring vigorous stress on the heart, lungs and muscles, the general efficiency of physiological functions is being improved. Research now strongly has the

theory that regular and vigorous exercise helps to keep the heart health and may prevent cardio respiratory diseases. A physically fit heart beats at a lower rate and pump more oxygen, which denotes the substantial increase of ability to do more physical work. People who keep fit greatly enlarge their fullness of living.

The resting heart rate is a person's heart rate when they are at rest, that is lying down but awake, and not having recently exerted themselves. The typical resting heart rate in adults is 60-80 bpm, with rates below 60 bpm referred to as bradycardia, and rates above 100 bpm referred to as tachycardia. Conditioned athletes often have resting heart rates below 60 bpm. The low pulse in conditioned athletes is due to the reduced demand on the heart by the peripheral muscles due to their greater efficiency. Hypertrophy, which is enlargement and thickening of cardiac muscle tissue can also account for a lower heart rate, therefore enabling a higher volume of blood being pumped at each beat

Athletic heart syndrome, also known as athlete's heart or athletic bradycardia, is a non-pathological condition commonly seen in sports medicine, in which the human heart is enlarged, and the resting pulse lowers, due to significant amounts of exercise, commonly aerobic exercise, and especially in endurance sports. Athlete's heart is common in athletes who routinely exercise more than an hour a day, and appears occasionally among heavy weight trainers. The condition is generally believed to be a benign, but may sometimes be hard to distinguish from other serious medical conditions.

For example, the results of medical tests such as an electrocardiogram can be mixed up with those of a serious heart disease by mistake.

Maximum Aerobic capacity (VO_2max) is very important concept in the field of exercise physiology; it is defined as the volume of oxygen consumed at maximum effort in the last 30 sec breathing air of sea-level. Aerobic capacity or VO_2max is related to body size, body fat%, diffusion capacity, functional capacity of cardiovascular system, the cellular metabolic process and cardiac output. Sex difference in VO_2max is attributed to a lower blood Hb concentration and low lean body mass in females after the onset of puberty. At full maturity, average North American female is approximately 13 cm shorter, 15-18 kg lighter with 25% body fat as compared to 15% body fat in male. The relationship of aerobic capacity and chronological age is evident. A positive relationship with age exists in the first 18 years of life in both male and female sedentary group and reaches a peak at the age of 25 yrs (40-45 ml/kg/min) and then decline to 20-30 ml/kg/min at the age of 60 yrs. This is due to reduction of absolute aerobic power and partly for an increase in body weight after 30 yrs of age.

Training can improve VO_2max from 0-44%. Effect of training can improve VO2 max from 0-44%. Effect of training on VO_2max depends on (a) Initial level of fitness (b) Type of training (duration, intensity and volume) (c) Physical characteristics of the person. Environmental factors viz. altitude, hot, cold, pollution etc. affect VO_2max. about 70% of VO_2max is determined by the genetic endowment of the individual. Dietary manipulation/ supplementation

affect VO_2max. lack of optimal diet reduces max O2 uptake by affecting the growth of the individual. No change or slight decrease in oxygen consumption at sub-maximal exercise. The decrease is due to an increase in mechanical efficiency. A decrease in O2 consumption is most pronounced in comparisons of highly trained athletes and untrained individuals. The difference is also evident between good and average runners. At maximal effort, VO_2max is increased. The increment is due to an increased oxygen delivery to the working muscles through an increased cardiac output and by an increased oxygen extraction from the blood by the skeletal muscles. The average improvement of 5-20% can be anticipated for college male and female student following 8-12 weeks of methodical training. Several studies have shown that even when the VO_2max is not much increased significant improvement in anaerobic threshold level is possible, provided the training schedule is administered at anaerobic threshold. Significant improvement in VO_2max may not be possible when the runner reaches a plateau. It is, therefore, suggested that more emphasis should be given to improve the anaerobic threshold level of athletes.

1.9: Body Composition

The body is composed of water, protein, minerals, and fat. A two-component model of body composition divides the body into a fat component and fat-free component. Body fat is the most variable constituent of the body. The total amount of body fat consists of essential fat and storage fat. Fat in the marrow of bones, in the heart, lungs, liver, spleen, kidneys, intestines, muscles and lipid-rich tissues throughout the central nervous system is called essential

fat, whereas fat that accumulates in adipose tissue is called storage fat. Essential fat is necessary for normal bodily functioning. The essential fat of women is higher than that of men because it includes sex-characteristic fat related to childbearing. Storage fat is located around internal organs (internal storage fat) and directly beneath the skin (subcutaneous storage fat). It provides bodily protection and serves as an insulator to conserve body heat. The relationship between subcutaneous fat and internal fat may not be the same for all individuals and may fluctuate during the life cycle.

Body composition is the proportion of the lean body mass and depot fat and it is one of the most important morphological features characterizing human organization. Ideal body fat levels for men are 12% to 17% and 18% to 22% for women. Body fat is essential for certain bodily functions. Body composition assessment has revealed that athletes generally have physique characteristics unique to their specific sports. For example, field events athletes have large quantities of lean tissue and a high percent body fat whereas long distance runners have the least amount of lean body and fat weight. Now a day's body composition is considered one of the components of fitness as it plays important role in developing fitness (Singh et al., 2004).

Fat is an essential components of the human body, critical in maintaining normal physiological function and homeostasis. The majority of body fat is stored in adipose tissue in subcutaneous sites. There are some deposited around vital organs to play a primarily protective role in the case of trauma (Malina et al., 2004). However, elevated body fat composition is

undesirable, given the strong associations to various diseases including coronary heart disease and non-insulin dependent diabetes mellitus (Gidding et al., 2004; Hardly et al., 2004). Asthma (Tantisira & Weiss, 2001), some cancers and hypertension has been associated with cardiovascular disease (Higashi et al., 2003) and osteoporosis (Ravan et al., 1999).

The relative proportion of fat-free mass to fat mass in the body. Fat-free mass is composed of muscle, bone, organs and water whereas, fat is the underlying adipose tissue. Excessive fat is a good predictor of health problems because it is associated with cardiovascular disease, high cholesterol, and high blood pressure. Higher proportions of fat-free mass indicate an increase in muscle, and thus an increased ability to adapt to everyday stress.

Worldwide rates of obesity increasing steadily, the National Institutes of Health (NIH) and the World Health Organization (WHO) recently adopted similar body weight guidelines for overweight and obesity (US DHHS, 1998; WHO, 1998). Values of body weight adjusted for height, referred to as body mass index (BMI; in kg/m^2), in excess of 25 and 30 are considered to indicate overweight and obesity, respectively. A lower healthy BMI limit of 18.5 was also identified by both organizations (US DHHS, 1998; WHO, 1998). These body weight guidelines are useful for practitioners when screening patients for excessive adiposity and when prescribing treatment for overweight patients. A number of studies suggest that the variation in body fat phenotypes or obesity is related to genetic variation.

Changes in diet and/or exercise patterns are the primary ways for one to lose weight. A change in diet facilitates weight loss by restricting total caloric as well as fat intake. A change in exercise patterns also facilitates weight loss by increasing caloric and fat expenditure (Keim et al., 1990). Even though individuals may attempt to lose weight, many never meet their goals. Weight loss programs often lack the two major elements needed for long-term adherence enjoyment and results. Someone may diet and exercise for a brief time, however, a lack of change in either appearance or weight (Grediagin et al., 1995) and a lack of time or interest (Willis & Campbell, 1992) may prevent adherence to the weight loss program.

The human body consists of several components including fat mass, lean muscle mass, skeletal bone mass and total body water. The proportions of each of these components have important implications for present and future health outcomes including cardiovascular, nutritional and psychological status as well as physical performance capability (Donnelly et al., 1996; Salbe et al., 2002; Ribeiro et al., 2003).

The relationship between densitometrically-determined body fat percentage (BF%) and BMI, taking age and sex into account internal and external cross-validation of the prediction formulas showed that they gave valid estimates of body fat in males and females at all ages. In obese subjects, however, the prediction formulas slightly overestimated the BF%. The prediction error is comparable to the prediction error obtained with other

methods of estimating BF%, such as skin fold thickness measurements or bioelectrical impedance.

The main assumption of BMI guidelines is that body mass, adjusted for stature squared, is closely associated with body fatness and consequent morbidity and mortality (Bray, 1996; Cole, 1991). However, some individuals who are overweight are not over fat. Others have BMIs within the normal range and yet have a high percentage of their body weight as fat. Although these misclassified persons are uncommon relative to the population as a whole (US DHHS, 1998), the question arises as to how they might be evaluated correctly according to body fatness. Moreover, screening and retention of military recruits (Committee on Body Composition, 1998) policemen, firemen (Gledhill & Jamnik, 1992) and other workers in whom high fitness levels are required are often based on BMI standards and in some cases on a second-tier body fat evaluation.

1.10: Need of the Study

Performance in any sports activity depends to a large extent on physical fitness and physiological components. Sports trainers concentrate on improving the physical fitness and physiological components of a player. Improving the physical and physiological fitness of a player is also called conditioning. A sound conditioning programme forms the most important part of training any sports person. Conditioning or physical and physiological fitness is categorized into general and specific fitness. General fitness refers to the common qualities required for any sports person irrespective of the sport i.e., motor qualities such

as strength, endurance, flexibility and coordination ability. Every sport demands motor abilities at various levels above the average. Specific fitness is achieved when a player acquires the required motor ability at the intensified level for the particular sport.

In the modern competitive sports, seriousness towards work and workouts plays important role in achieving high performance in competitions. Outstanding players have been found to be more sober, disciplined, practical, and tough-minded. Competitions now a day are so tough that only those achieve high performance who trains for long hours. Kabaddi is although game requiring high physical fitness and quick reflexes. One has to work hard and tolerate mental strain besides physical stress of training. There is no place for a tender minded person in competitive kabaddi. Self-discipline and confidence are other qualities that are required to obtain high performance in kabaddi. The kabaddi players face more man-to-man combats and hence require physical and mental toughness.

The changing nature of the game Kabaddi, demands the right type of physical, physiological abilities on the part of a player. The increasing trend of professionalism and the converging demand for competitive sports have changed the complexion of the games which had been initially intended as a recreational activity of the villagers. Today with the adventure of modern scientific equipments for training and selection of the players, it has been now made possible to measure the fundamental performance characteristics which contribute to a player's success.

Resistance training has been reported to cause muscle fibre hypertrophy, associated with an increase in contractile protein, which contributes to an increase in maximal contractile force (Sale et al., 1990). Strength training also reduces mitochondrial density and suppresses oxidative enzymes activity which can cause impede endurance capacity, but has minimal impact on capillary density or in the conversion of muscle fibre types from fast twitch (type-II fibres) to slow twitch (type-I fibres) (Nelson et al., 1990; Sale et al., 1990). In contrast, endurance training usually causes little or no muscle fibre hypertrophy, but it does induce increases in mitochondria content, citric acid enzymes, oxidative capacity and the possibility of muscle fibre conversion from fast twitch to slow twitch (Bell 1991, Nelson et al., 1990).

Detraining is equally important but that has been given considerably less attention by the athletes and the coaches and practically ignored by the research scholars in exercise and sports sciences. Detraining induces a partial or complete loss of training induced adaptations in response to insufficient training stimuli. It has been suggested by Wilmore and Costill (1994) that untrained individuals who train and produce significant improvements on speed, anaerobic power and aerobic endurance, lose some conditioning within two weeks of detraining. Baechle (1994) stated that when detraining occurs, the physiological function goes back to the normal untrained state of the individual.

The influence of detraining on physical, physiological and body composition parameters has received little attention and not completely

understood. Few studies have only assessed the longevity of changes after training on physical, physiological and body composition parameters. Consequently, the aim of the present study was to investigate the effectiveness of resistance training and detraining impact on selected physical, physiological and body composition parameters of kabaddi players.

1.11: Statement of the Problem

Though there are several training methods, which are recommended for the improvement of physical fitness, physiological and body composition parameters, the impact of resistance training and detraining has not been conducted in an exhaustive manner in India among inter-collegiate kabaddi players. Therefore, the investigator reviewed literature and found scarcity of studies on training and detraining on selected physical fitness, physiological and body composition parameters.

Determining the effect of resistance training and detraining on selected variables are useful to research objectives and it has drawn the attention of the investigator. The present scientific study is one of such effort to explore the effect of resistance training and detraining impact on selected physical fitness, physiological and body composition parameters of inter-collegiate kabaddi players.

1.12: Objectives of the Study

The primary research objectives are the following:

1. To analyze the changes on selected physical fitness, physiological and body composition parameters of kabaddi players due to the effect of resistance training.
2. To investigate how long the training effect shall last or be maintained after the cessation of training and the rate of decrease.

1.13: Hypotheses

The researcher had gone through various related research studies completed on this area. Based on the available literatures, keeping the logical concepts, the following hypotheses have been formulated.

1. There would be significant changes on selected physical fitness, physiological and body composition parameters of inter-collegiate kabaddi players due to the effect of resistance training.
2. The changes on selected physical fitness, physiological and body composition parameters of inter-collegiate kabaddi players as a result of resistance training would be altered significantly due to the impact of cessation of training.

1.14: Significance of the Study

The findings of this study will be of significant in the following ways:

1. The findings of the study may add to the existing source of knowledge with regard to the training and detraining among kabaddi players on physical fitness, physiological and body composition parameters.

2. The findings of the study will add to the quantum of knowledge in the level of improvement on selected dependent variables.
3. This study may help to know the physical fitness, physiological and body composition changes among kabaddi players due to the resistance training and detraining.
4. This study provides a prospect to the physical educators, exercise physiologists, coaches and athletes to scientifically understand and weigh up the changes in the physical fitness, physiological and body composition parameters.
5. This study may help the Coaches and Physical Educators to train the kabaddi players to improve the selected physical fitness, physiological and body composition.
6. This research may help the sports scientists to suggest ways and means to improve better standard in sports through this specific type of resistance training.
7. The results of this study will give a clear picture to the sports coaches that the particular resistance training programme will help to improve the strength of the kabaddi players. This study will provide an opportunity to test kabaddi players in the selected physical fitness, physiological and body composition variables.
8. This study will give a clear conception to the researcher, whether the resistance training and detraining influences the selected physical fitness, physiological and body composition variables of the kabaddi players.

9. The findings of this investigation will be of great importance and add to the body of knowledge in the field of physical education and sports.
10. This study stimulates the kabaddi players' interest in activities through self evaluation of the performance they do and the importance they show.
11. This study may provide clear guidelines in better performance to be groomed for higher levels of competition.
12. The result of the study may be helpful to physical education teacher, coach in designing the training programs to improve performance according to the individual concerned.
13. The result of this study would also help the physicians, physical education teachers and coaches to know how long the training effect shall last or be maintained after the cessation of training and the rate of deterioration.

1.15: Limitations

The following uncontrollable factors associated with the study are considered as limitations of the study.

1. The environmental factors such as, climatic condition, atmospheric pressure, temperature and humidity during the twelve weeks of training period and collection of the data was not taken into consideration.
2. The previous experience of the subjects in the training was not considered in this study.
3. The emotional status of the subjects during the training period and testing period was not given importance.

4. The influence of vigorous academic activity of students could have discouraged or motivated the subjects during training and during testing period.
5. The heterogeneous characters of the subjects in hereditary and environmental factors were recognized as a limitations.
6. The subject's body type and socio economic status of the students were not taken into consideration.
6. While training and testing, the factors like personal habits, life style and other domestic involvements of the subjects, which may influence the results of the study were not taken into consideration.

1.16: Delimitations

The study is delimited to the following factors.

1. Thirty inter collegiate men kabaddi players studying in various colleges affiliated to Manonmanium Sundaranar University, from kanyakumari district, India during the academic year 2016-2017 were selected as subjects and their age ranged from 18 to 22 years and they were divided into two equal groups of fifteen each (n=15) at random.
2. Group-I performed resistance training and group-II acted as control.
3. The duration of the training period was restricted to twelve weeks and the number of sessions per week is confined to three.
4. The physical variables were delimited to muscular strength and explosive power.

5. The physiological parameter was delimited to resting heart rate and maximum oxygen consumption.
6. The body composition parameter was delimited to percent body fat and body mass index.
7. The level of significance was fixed at 0.05 levels, which was considered to be appropriate.
8. The data was collected on selected dependent variables two days prior and immediately after the twelve weeks training period and also .

1.17: Definitions of the Terms

1.17.1: Training

Training is the systematic process of repetitive progressive exercise or work involving also learning process and acclimatization.

1.17.2: Sports training

Sports training is a process of preparation of sportsman, based on scientific and pedagogical principles for higher performance (Singh, 1993).

1.17.3: Resistance Training

Resistance training is an exercise programme where free or stationary weights are used for the purpose of increasing muscular strength, muscular endurance and power through which skills can be improved (Moran & McGlynn, 1990).

Resistance training can be defined as a practice where in the actual skills are performed against resistance by adding weights either on different members

of the body or on the implements used in various games and sports.(Singh, 1991).

1.17.4: Kabaddi

Kabaddi is a combative team game, played with absolutely no equipment, in a rectangular court, either out doors of indoors with seven players on the ground in each side. Each side takes alternate chances at offense and defense. The basic idea of the game is to score points by raiding into the opponents' court and touching as many defense players as possible without getting caught on a single breath.

1.17.5: Physical Fitness

Physical fitness is the ability to perform occupational, recreational and daily activities without becoming unduly fatigued.

Physical fitness is the ability to carry out daily takes with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies.

1.17.6: Muscular Strength

Strength is one of the very important aspects of fitness. It contributes to power, muscular endurance, sports performance and consequently in imperative to the athletes. It is the pulling force or tension exerted by a muscle during contraction. It is the ability of the body to apply force **(**Parks & Zanger, 1996).

According to Fukushima (1978), muscular strength is the amount of tension (Kilogram or Pounds) a muscle or group of muscles can exert in one maximum contraction.

1.17.7 Explosive Power

Explosive Power is defined as the ability of the muscle or group of muscles release maximum force in the shortest possible time, in an explosive manner, projecting the body or object (Clarke, 1976).

1.17.8: Resting Heart Rate

"Pulse rate is actually the frequency of pressure waves (per minute) propagated along the peripheral arteries" (Astrand & Radahe, 1970).

"The number of beats felt in exactly one minute is the pulse rate" (Brindwasper, 1966).

Resting heart rate will decrease as the subject's heart becomes larger and stronger with training. A low resting heart rate is an indicator of fitness.

1.17.9: Maximum Oxygen Consumption

It is the maximal capacity for oxygen consumption by the body during maximal exertion. It is also known as aerobic power, maximal oxygen consumption, and cardio-respiratory endurance capacity (Wilmore & Costill, 1994).

1.17.10: Body Composition

Body composition refers to the proportion of fat and fat-free mass in the body. Those with a higher proportion of fat-free mass to a lower proportion of body fat have a healthy body composition.

Body composition will typically be displayed as either a percentage of fat (body fat percentage or %fat) or as a percentage of lean body mass (LBM)**.**

1.17.11: Percent Body Fat

A measurement of the amount of fat in human body is usually expressed as a percentage of total body weight.

Once body density was determined, the percent body that was computed from the equation is given below:

$$\text{Percent body fat} = \left[\frac{4.570}{\text{Density}} - 4.142\right] \text{x } 100$$

1.17.12: Body Mass Index

An estimation of body composition used especially in epidemiological studies. It is an indicator of obesity on the assumption that the higher the index the greater the level of body fat (Michael, 1994).

BMI = Weight in Kilogram/ Height in meters^2.

Chapter II

REVIEW OF RELATED LITERATURE

A complete knowledge of the sports and its growth and development was felt imperative in order to facilitate such a study. Hence an extensive reading and collection was done by going through text books, magazines, journals, and research quarterly available in the libraries of various physical education colleges in Tamil Nadu and also through internet sources which in turn helped the researcher to focus on the study.

The phrase "Review of Literature" consists of two words "Review" and "Literature". In research methodology the term literature refers to the knowledge of a particular area of any discipline, which includes theoretical, practical and its research studies. The literature in any field forms the foundation upon which all future work will be built. If we fail to build upon the foundation of knowledge provided by the review of literature, the researcher might fail to know the related issues or work already done on the similar topic.

The researcher finds out some of the review of literature which could be very supportive and strengthen this study. The reviews of the literature have been classified under the following headings such as studies pertaining to resistance training and studies pertaining to detraining.

2.1: Studies Pertaining to Resistance Training

Aidar et al., (2017) aimed to evaluate the effect of resistance training on the functional capacity of people with multiple sclerosis. Two groups were defined intentionally and divided based on the Expanded Disability Status

Scale (EDSS): an experimental group (EG) consisting of 11 individuals, 18.2% with an EDSS Score of 0 - 3.0, 72.8% with a score of 3.5 - 5.5 and 9.1% with a score of 6.0 - 7.5; and a control group (CG) consisting of 12 subjects, 25.0% with a score of 0 - 3,0, 58.3% with a score of 3,5 - 5,5 and 16.7% with a score of 6,0 - 7,5. The EG underwent 12 weeks of resistance training, while the CG did not. The Timed "Up & Go" test was used to measure the function of the lower limbs. The Timed 7.62 Meters Walk test and the Sit-to-stand test were used to assess the strength of the lower limbs. Balance, and the risk of falling, were assessed through the Berg balance test. At the beginning of the study, there were no differences between EG and CG in lower limb function. However, after the 12 weeks of resistance training, significant differences were found between the EG and the CG in the Timed "Up and Go" test ($p = 0.021$), Timed 7.62 Meters Walk ($p = 0.027$), Sit-to-stand ($p = 0.017$) and Balance test ($p = 0.039$). This study's results indicate that this type of training can improve muscle strength and functional capacity in patients with multiple sclerosis.

Fernández-Lezaun (2017) investigated the effects of resistance training (RT) performed with different frequencies, including a follow-up period, on cardiorespiratory fitness in healthy older individuals. Eighty-eight men and women (69 ± 3 years, 167 ± 9 cm and 78 ± 14 kg) were randomly placed into four groups: training one- (M1 = 11, W1 = 12), two- (M2 = 7, W2 = 14), or three- (M3 = 11, W3 = 13) times-per-week or a non-training control group (MCon = 11, WCon = 9). During months 1–3, all subjects trained two-times-per-week while during the subsequent 6 months, training frequency was set

according to the group. Oxygen consumption (cycling economy: CE), gross efficiency (GE), blood lactate concentrations (La) and heart rate (HR) were evaluated during a submaximal cycle ergometer test. Hemoglobin (Hb), hematocrit (Hct), heart rate (HRrest) and body composition by DXA were also measured at rest. Maximal strength was measured by a 1-RM leg press test. Most improvements in CE, GE, La and HR occurred in all groups during months 1–3. No additional statistically significant improvements were observed during months 4–9, although effect sizes for the change in CE and GE at higher workloads indicated a dose-response pattern in men (CE at 75 W: M1 g = 0.13, M2 g = − 0.58, M3 g = − 0.89; 100 W: M1 g = 0.43, M2 g = − 0.59, M3 g = − 0.68) i.e. higher training frequency (two- and three-times-per-week versus one-time-per-week) led to greater improvements once the typical plateau in performance had occurred. Hb increased in W1 and W2, while no changes were observed in Hct or HRrest. 1-RM increased from months 1–3 in all intervention groups (except M2) and from month 4–9 only in M3 and in all women intervention groups. During follow-up, maximal strength was maintained but cycling economy returned to the baseline values in all training groups. These data indicate that RT led to significant improvements in cardiorespiratory fitness during the initial 3 months of training. This was partly explained by the RT protocol performed but further improvements may require higher training frequency. These changes are likely to be originated by the improved cardiorespiratory functions rather than neuromuscular adaptations

evidenced by a lack of significant relationship during the intervention as well as the divergent results during follow-up.

Lopes (2017) evaluated the impact of moderate-load (10 RM) and low-load (20 RM) resistance training schemes on maximal strength and body composition. Sixteen resistance-trained men were randomly assigned to 1 of 2 groups: a moderate-load group (n = 8) or a low-load group (n = 8). The resistance training schemes consisted of 8 exercises performed 4 times per week for 6 weeks. In order to equate the number of repetitions performed by each group, the moderate load group performed 6 sets of 10 RM, while the low load group performed 3 sets of 20 RM. Between-group differences were evaluated using a 2-way ANOVA and independent t-tests. There was no difference in the weekly total load lifted (sets × reps × kg) between the 2 groups. Both groups equally improved maximal strength and measures of body composition after 6 weeks of resistance training, with no significant between-group differences detected. In conclusion, both moderate-load and low-load resistance training schemes, similar for the total load lifted, induced a similar improvement in maximal strength and body composition in resistance-trained men.

James et al., (2017) examined the progressive implementation of a high effort resistance training (RT) approach in older adults over 6 months and through a 6-month follow-up on strength, body composition, function, and wellbeing of older adults. Methods. Twenty-three older adults (aged 61 to 80 years) completed a 6-month supervised RT intervention applying progressive

introduction of higher effort set end points. After completion of the intervention participants could choose to continue performing RT unsupervised until 6-month follow-up. Results. Strength, body composition, function, and wellbeing all significantly improved over the intervention. Over the follow-up, body composition changes reverted to baseline values, strength was reduced though it remained significantly higher than baseline, and wellbeing outcomes were mostly maintained. Comparisons over the follow-up between those who did and those who did not continue with RT revealed no significant differences for changes in any outcome measure. Conclusions. Supervised RT employing progressive application of high effort set end points is well tolerated and effective in improving strength, body composition, function, and wellbeing in older adults. However, whether participants continued, or did not, with RT unsupervised at follow-up had no effect on outcomes perhaps due to reduced effort employed during unsupervised RT.

Bieler and Sobol (2014) investigated the effects of high-intensity (HRT) versus low-intensity (LRT) resistance training on leg extensor power and recovery of knee function after ACL-reconstruction. Thirty one males and ninteen females were randomized to HRT (n = 24) or LRT (n = 26) from week 8-20 after ACL-reconstruction. Leg extensor power, joint laxity, and self-reported knee function were measured before and 7, 14, and 20 weeks after surgery. Hop tests were assessed before and after 20 weeks. Power in the injured leg was 90% (95% CI 86-94%) of the non-injured leg, decreasing to 64% (95% CI 60-69%) 7 weeks after surgery. During the resistance training

phase there was a significant group by time interaction for power (P = 0.020). Power was regained more with HRT compared to LRT at week 14 (84% versus 73% of noninjured leg, resp.; P = 0.027) and at week 20 (98% versus 83% of noninjured leg, resp.; P = 0.006) without adverse effects on joint laxity. No other between-group differences were found. High-intensity resistance training during rehabilitation after ACL-reconstruction can improve muscle power without adverse effects on joint laxity.

Krist, Dimeo and Keil (2013) determined the effects of progressive resistance training on mobility, muscle strength, and quality of life in nursing-home residents with impaired mobility. Nursing-home residents aged 77 years and older with impaired mobility were recruited in Berlin, Germany. The eight-week exercise program consisted of progressive resistance training twice a week. Mobility (primary outcome) was assessed with the Elderly Mobility Scale (zero = worst, 20 = best) at baseline and after 8 weeks. Muscle strength (secondary outcome) was determined by the eight-repetition maximum. The Short Form-36 Health Survey was used to assess quality of life. Of the 15 participants (mean age 84 years, range 77-97 years), ten completed the 8-week program. Mobility (Elderly Mobility Scale mean ± standard deviation pre 14.1 ± 3.2 and post 17.5 ± 3.6; P = 0.005) as well as muscle strength of upper and lower limbs improved (from 62% at chest press up to 108% at leg extension machine), whereas most quality of life subscales did not show considerable change. Resistance training twice a week over 2 months seemed to

considerably improve mobility and muscle strength in persons aged 77-97 years with impaired mobility.

Liossis et al., (2013) examined the acute effect of upper body complex training on power output, as well as to determine the requisite preload intensity and intra-complex recovery interval needed to induce power output increases. Nine amateur-level combat/martial art athletes completed four distinct experimental protocols, which consisted of 5 bench press repetitions at either: 65% of one-repetition maximum (1RM) with a 4 min rest interval; 65% of 1RM with an 8 min rest; 85% of 1RM with a 4 min rest; or 85% of 1RM with an 8 min rest interval, performed on different days. Before (pre-conditioning) and after (post-conditioning) each experimental protocol, three bench press throws at 30% of 1RM were performed. Significant differences in power output pre-post conditioning were observed across all experimental protocols ($F=26.489$, partial $eta2=0.768$, $p=0.001$). Mean power output significantly increased when the preload stimulus of 65% 1RM was matched with 4 min of rest ($p=0.001$), and when the 85% 1RM preload stimulus was matched with 8 min of rest ($p=0.001$). Moreover, a statistically significant difference in power output was observed between the four conditioning protocols ($F= 21.101$, partial $eta(2)=0.913$, $p=0.001$). It was concluded that, in complex training, matching a heavy preload stimulus with a longer rest interval, and a lighter preload stimulus with a shorter rest interval is important for athletes wishing to increase their power production before training or competition.

Sherk et al., (2012) conducted a study on the effects of resistance training duration on muscular strength retention 6-month post training in older men and women. Twenty five men and 44 women (aged 55–75 years) who returned for testing 6 months after training, 38 had continued to exercise on their own (Ex) and 31 stopped training (NoEx). This represents 40.8% of the original 169 participants that were contacted. Individual measures of strength were averaged to represent a measure of mean upper body or lower body strength. Changes in mean 1RM (one repetition maximum) strength and percent changes in strength were analyzed for pre (pretraining), post (posttraining), and 6MP (6 months post) time points by mixed-factor ANOVAs (analyses of variance). The results showed that the upper and lower body strengths were still significantly higher than baseline values, 6MP training for both groups. However, the longer-duration (80 week) training program provided a greater, although non–statistically significant, ability to maintain strength at higher levels at 6MP training compared to the strength values obtained at the end of the two different training periods. In addition, lower body strength was better maintained than measures of upper body strength independent of initial training duration. Supervised strength training represents an efficacious intervention for improving strength in older adults with residual benefits lasting longer than previously expected.

Zavanela et al., (2012) examined the health and fitness benefits of a resistance training intervention performed in the workplace. The subjects (untrained men bus drivers) were recruited from a bus company and divided

into a training (n = 48) and control (n = 48) groups after initial pre screening. The training group performed a 24-week resistance training program, whereas the control group maintained their normal daily activities. Each group's health and fitness were assessed before and after the 24-week training period. The study was concluded that a periodized resistance training intervention performed within the workplace improved different aspects of health and fitness in untrained men, thereby potentially providing other work-related benefits.

Hayes, Gappmaier and Lastayo, (2011) evaluated the **e**ffects of high-intensity resistance training on strength, mobility, balance, and fatigue in individuals with multiple sclerosis. Nineteen individuals with MS (8 men, 11 women; age mean = 49 ± 11 years; Expanded Disability Status Scale [EDSS] mean = 5.2 ± 0.9) were randomized into either standard exercise (STAND) or standard exercise and RENEW training (RENEW) for 3×/week for 12 weeks. Outcome measures were lower extremity strength (hip/knee flexion and extension, ankle plantar and dorsiflexion, and the sum of these individual values [sum strength]); Timed Up and Go (TUG), 10-m walk, self-selected pace (TMWSS) and maximal-pace (TMWMP), stair ascent (S-A) and descent (S-D) and 6-Minute Walk Test (6MWT), Berg Balance Scale (BBS), Fatigue Severity Scale (FSS). No significant time effects or interactions were observed for strength, TUG, TMWSS, TMWMP, or 6MWT. However, the mean difference in sum strength in the RENEW group was 38.60 (representing a 15% increase) compared to the sum strength observed in the STAND group

with a mean difference of 5.58 (a 2% increase). A significant interaction was observed for S-A, S-D, and BBS as the STAND group improved whereas the RENEW group did not improve in these measures.

Cowley et al., (2011) examined the effect of progressive resistance training on leg strength, aerobic capacity and functional tasks of daily living in persons with Down syndrome. Thirty persons with DS (age 28 SD 8 years) were assigned to an intervention or control group. The intervention group performed resistance training 2 days per week for 10 weeks. Participants performed tests to measure isometric and isokinetic knee extensor and flexor peak torque, peak aerobic capacity and timed performance on chair rise, walking and stair ascent and descent. The results showed that persons with DS receiving the intervention significantly increased their isokinetic knee extensor and flexor peak torque [Absolute change (post minus pre-value) was 17.0 SD 29.6 and 12.6 SD 18.9 N m, respectively] and isometric knee extensor peak torque at angles of 45° (2.9 SD 23.2 N m), 60° (3.0 SD 22.9 N m) and 75° (14.2 SD 30.0 N m). These changes were significantly greater than in the control group. In addition, the time to ascend (-0.3 SD 0.8s) and descend (-0.6 SD 0.9s) stairs significantly decreased in the intervention group compared to the control group. These findings show that progressive resistance training is an effective intervention for persons with DS to improve leg strength and stair-climbing ability.

Chiung-ju et al., (2011) examined the effects of upper-extremity progressive resistance strength training in older adults: the missing picture.

Age-related decline in muscle strength affects both upper and lower extremities. This decline is associated with late-life onset of physical disability. Although progressive resistance strength training (PRT) has shown promising results in lower-extremity-related physical function, such as walking speed, little is known about the effect on upper-extremity-related physical function. This study reviewed 28 randomized controlled trials published before 2008. Outcomes of upper-extremity muscle strength, hand-grip strength, eye–hand coordination, and physical function were appraised. It is hard to conclude whether or not upper-extremity PRT is beneficial for upper-extremity-related physical function in older adults because the specific effect of upper extremities was often unmeasured, poorly measured with timed tests, or buried in mixed results of upper and lower extremities. Additional research that focuses on examining the effect of upper-extremity PRT is recommended to support the need for a comprehensive muscle strength training program.

Miranda et al., (2011) investigated the effects of linear vs. daily undulatory periodized resistance training on maximal and submaximal strength gains. Twenty resistance trained men were randomly assigned to 2 training groups: linear periodization (LP) group and daily undulating periodization (DUP) group. The subjects were tested at baseline and after 12 weeks for 1RM and 8RM loads in leg press (LEG) and bench press (BP) exercises. The training program was performed in alternated sessions for upper (session A: chest, shoulder and triceps) and lower body (session B: leg, back and biceps). The 12-week periodized training was applied only in the tested exercises, and in the

other exercises, 3 sets of 6-8RM were performed. Both groups exhibited significant increases in 1RM loads on LEG and BP, but no statistically significant difference between groups was observed. The same occurred in 8RM loads on LEG and BP. However, DUP group presented superior effect size (ES) in 1RM and 8RM loads for LEG and BP exercises when compared to the LP group. In conclusion, periodized RT can be an efficient method for increasing the strength and muscular endurance in trained individuals. Although there was no statistically significant difference between periodization models, DUP promoted superior ES gains in muscular maximal and submaximal strength.

Larose et al., (2010) evaluated the effects of aerobic exercise training (A group), resistance exercise training (R group), combined aerobic and resistance training (A + R group), and sedentary lifestyle (C group) on cardiorespiratory fitness and muscular strength in individuals with T2DM. Two hundred and fifty-one participants in the Diabetes Aerobic and Resistance Exercise trial were randomly allocated to A, R, A + R, or C. Peak oxygen consumption (V O(2peak)), workload, and treadmill time were determined after maximal exercise testing at 0 and 6 months. Muscular strength was measured as the eight-repetition maximum on the leg press, bench press, and seated row. Responses were compared between younger (aged 39-54 yr) and older (aged 55-70 yr) adults and between sexes. VO(2peak) improved by 1.73 and 1.93 mL O(2)*kg(-1)*min(-1) with A and A + R, respectively, compared with C ($P < 0.05$). Strength improvements were significant after A + R and R on the leg

press (A + R: 48%, R: 65%), bench press (A + R: 38%, R: 57%), and seated row (A + R: 33%, R: 41%; P < 0.05). There was no main effect of age or sex on training performance outcomes. There was, however, a tendency for older participants to increase VO(2peak) more with A + R (+1.5 mL O(2)*kg(-1)*min(-1)) than with A only (+0.7 mL O(2)*kg(-1)*min(-1)). Combined training did not provide additional benefits nor did it mitigate improvements in fitness in younger subjects compared with aerobic and resistance training alone. In older subjects, there was a trend to greater aerobic fitness gains with A + R versus A alone.

Aagaard and Andersen (2010) conducted a study on the effects of strength training on endurance capacity in top-level endurance athletes. The enhancement in endurance capacity appears to involve training-induced increases in the proportion of type II muscle fibers as well as gains in maximal muscle strength (MVC) and rapid force characteristics also enhancements in neuromuscular function.

Dorgo et al., (2009) conducted a study to investigate the effects of a manual resistance training (MRT) program on muscular strength and endurance and to compare these effects with those of identically structured weight resistance training (WRT) program. To do this, 84 healthy college students were randomly assigned to either or WRT group and engaged in a 14-week training program. The improvements in muscular strength and muscular endurance after a 14-week MRT program were similar to those produced by a

WRT program, and well-designed MRT exercises seem to be effective for improving muscular fitness.

Hanson et al., (2009) determined the effects of strength training (ST) on physical function and (b) the influence of strength, power, muscle volume (MV), and body composition on physical function. Healthy, inactive adults (*n* = 50) aged 65 years and older underwent strength, power, total body composition (% fat and fat free mass [FFM]), and physical function testing before and after 22 weeks of ST. Physical function testing consisted of tasks designed to mimic common physical activities of daily living (ADL). To improve internal validity of the assessment of mid-thigh intermuscular fat, subcutaneous fat, and knee extensors MV, a 10-week unilateral ST program using the untrained leg as an internal control preceded 12 weeks of whole-body ST. Strength, power, and FFM increased significantly with ST (all $p < 0.05$), whereas rapid walk, 5 chair stands, and get up and go time decreased significantly with ST in the overall group (all $p < 0.05$). Women improved significantly in both walking test times (both $p < 0.05$) but not in the stair climb test, whereas men improved in the stair climb test ($p < 0.05$) but not in walking test times. Multiple regression analysis revealed the highest R^2 (0.28) for the change in chair stands time, followed by stair climb and usual walk at 0.27 and 0.21, respectively. ST improves performance in functional tasks important for ADLs. Changes in strength, power, and FFM are predictors of ST-induced improvements in these tasks.

Lamont et al., (2008) examined the effects of a 6-week, periodized squat training program, with or without whole-body low-frequency vibration (WBLFV), on jump performance. Males ranged in age from 20 to 30 years and were randomized into groups that did squat training with (SQTV, n = 13) or without (SQT, n = 11) vibration, or a control group (CG, n = 6). Measures of jump height (cm), peak power (Pmax), Pmax per kilogram of body mass (Pmax/kg), and mean power were recorded during 30-cm depth jumps and 20-kg squat jumps at weeks 1 (pretraining), 3 (midtraining), and 7 (posttraining). No significant group differences were seen for 30-cm depth jump height between weeks 1 and 7 ($p > 0.05$. Significant group differences were seen for 20-kg squat jump height, with SQTV > SQT between weeks 1 and 7 ($p < 0.05$). Significant trial differences were seen, with W7 > W3 > W1 ($p < 0.05$) as well as for 30-cm depth jump Pmax percent change (W7 > W3 and W1 $p < 0.05$)). A significant trial effect was seen for 20-kg squat jump Pmax (W7 > W1, $p < 0.05$) and 20-kg squat jump Pmax/kg percent change (W7 > W3 > W1, $p < 0.05$).

Ronnestad et al., (2008) compare the effects of combined strength and plyometric training with strength training alone on power-related measurements in professional soccer players. Subjects in the intervention team were randomly divided into 2 groups. Group ST (n = 6) performed heavy strength training twice a week for 7 weeks in addition to 6 to 8 soccer sessions a week. Group ST+P (n = 8) performed a plyometric training program in addition to the same training as the ST group. The control group (n = 7)

performed 6 to 8 soccer sessions a week. Pretests and posttests were 1 repetition maximum (1RM) half squat, countermovement jump (CMJ), squat jump (SJ), 4-bounce test (4BT), peak power in half squat with 20 kg, 35 kg, and 50 kg (PP20, PP35, and PP50, respectively), sprint acceleration, peak sprint velocity, and total time on 40-m sprint. There were no significant differences between the ST+P group and ST group. Thus, the groups were pooled into 1 intervention group. The intervention group significantly improved in all measurements except CMJ, while the control group showed significant improvements only in PP20. There was a significant difference in relative improvement between the intervention group and control group in 1RM half squat, 4BT, and SJ. However, a significant difference between groups was not observed in PP20, PP35, sprint acceleration, peak sprinting velocity, and total time on 40-m sprint. The results suggest that there are no significant performance-enhancing effects of combining strength and plyometric training in professional soccer players concurrently performing 6 to 8 soccer sessions a week compared to strength training alone. However, heavy strength training leads to significant gains in strength and power-related measurements in professional soccer players.

Christou et al., (2006) examined the effects of a progressive resistance training program in addition to soccer training on the physical capacities of male adolescents. Eighteen soccer players (age: 12-15 years) were separated in a soccer (SOC; n = 9) and a strength-soccer (STR; n = 9) training group and 8 subjects of similar age constituted a control group. All players followed a

soccer training program 5 times a week for the development of technical and tactical skills. In addition, the STR group followed a strength training program twice a week for 16 weeks. The program included 10 exercises, and at each exercise, 2-3 sets of 8-15 repetitions with a load 55-80% of 1 repetition maximum (1RM). Maximum strength ([1RM] leg press, bench-press), jumping ability (squat jump [SJ], countermovement jump [CMJ], repeated jumps for 30 seconds) running speed (30 m, 10 x 5-m shuttle run), flexibility (seat and reach), and soccer technique were measured at the beginning, after 8 weeks, and at the end of the training period. After 16 weeks of training, 1RM leg press, 10 x 5-m shuttle run speed, and performance in soccer technique were higher ($p < 0.05$) for the STR and the SOC groups than for the control group. One repetition maximum bench press and leg press, SJ and CMJ height, and 30-m speed were higher ($p < 0.05$) for the STR group compared with SOC and control groups. The above data show that soccer training alone improves more than normal growth maximum strength of the lower limps and agility. The addition of resistance training, however, improves more maximal strength of the upper and the lower body, vertical jump height, and 30-m speed. Thus, the combination of soccer and resistance training could be used for an overall development of the physical capacities of young boys.

Faigenbaum et al., (2006) compared the effects of a six week training period of combined plyometric and resistance training (PRT) or resistance training alone (RT) on fitness performance in boys. Healthy boys (N = 14, 12-14 yrs) were divided into two treatment groups to be trained twice a week for

six weeks: RT (N = 7) or PRT (N=7). The RT group performed static stretching exercises followed by resistance training whereas the PRT group performed plyometric exercises followed by the same resistance-training program. Both training sessions lasted 90 minutes. All subjects were pre- and post- tested on the vertical jump (VJ), long jump (LJ), medicine ball toss (MB), 10-yd. sprint (SP), pro-agility shuttle run (PRO), and flexibility (FX). It was stated that the PRT group improved significantly more than the RT group in long jump, medicine ball toss, and pro-agility shuttle run. There were no differences in vertical jump, 10-yd sprint, or flexibility. Combined plyometric and resistance training program might be more beneficial than resistance training alone for enhancing upper and lower body power in boys.

2.2: Studies Pertaining to Detraining

Tavares et al., (2017) investigated the effects of different reduced strength training (RST) frequencies on half-squat 1 RM and quadriceps cross-sectional area (QCSA). Thirty-three untrained males (24.7 ± 3.9 years; 1.73 ± 0.08 m; 74.6 ± 8.4 kg) underwent a 16-week experimental period (i.e. eight weeks of strength training [ST] followed by additional eight weeks of RST). During the ST period, the participants performed 3–4 sets of 6–12 RM, three sessions/week in half-squat and knee extension exercises. Following ST, the participants were randomly allocated to one of three groups: reduced strength training with one (RST1) or two sessions per week (RST2), and ceased training (CT). Both RST1 and RST2 groups had their training frequency and total training volume-load (i.e. RST1 = 50.3% and RST2 = 57.1%) reduced,

while the CT group stopped training completely. Half-squat 1 RM (RST1 = 27.9%; RST2 = 26.7%; and CT = 28.4%) and QCSA (RST1 = 6.1%; RST2 = 6.9%; and CT = 5.8%) increased significantly ($p < .05$) in all groups after eight weeks of ST. No significant changes were observed in 1 RM and QCSA for RST1 and RST2 groups after the RST period, while the CT group demonstrated a decrease in half-squat 1 RM (22.6%) and QCSA (5.4%) when compared to the ST period ($p < .05$). In conclusion, different RST frequencies applied were able to maintain muscle mass and strength performance obtained over the regular ST period. Thus, it appears that RST frequency does not affect the maintenance of muscle mass and strength in untrained males, as long as volume-load is equated between frequencies.

Suresh, Sakthignanavel and Ramesh (2014) analyzed the effects of yogic training, aerobic training and detraining on cardio-respiratory endurance of college male students. For this study 45 (forty five) healthy untrained subjects were selected on random basis. The students were selected from Dr.R.K.Shanmugam College of Arts & Science, Indili, Kallakurichi T.K Villupuram (Dt) in Tamil Nadu, India. The subject's age were ranged between 18 to 21 years. The selected subjects were divided into three groups, each group consist of fifteen (15) subjects. Group I underwent yogic training, group II underwent aerobic training and group III acted as a control group. The selected Asanas and Pranayama were given to yogic training group. The selected aerobic dance steps assigned for aerobic training group. The duration of the training period was stipulated to 12 weeks for 5 days per week (45

minutes). Control group was kept under control without any training. The cardio-respiratory endurance was measured by using 12- Minutes run / walk tests. Prior to and after the end of practice period all the subjects were tested on cardio-respiratory endurance. The results of pre, mid, post, first, second, and third cessation test were compared statistically analyzed by using two-way factorial analysis of variance with last factor repeated measures. The 'F' ratio value was statistically analyzed and tested for significant difference at 0.05 level of confidence.

Ormsbee and Arciero (2012) investigated whether detraining increases body fat and weight and decreases VO_2peak and metabolic rate. Eight healthy endurance-trained swimmers (VO_2peak, 46.7 ± 10.8 ml·kg·min) performed 2 identical test days, 1 in the trained (TR) state and 1 in the detrained (5 weeks) state (DT). Body composition and circumferences, maximal oxygen consumption (VO_2peak), resting metabolism (RMR), blood lipids, and mood state were measured. Their data suggest that DT after a competitive collegiate swim season adversely affects body composition, fitness, and metabolism. Athletes and coaches need to be aware of the negative consequences of detraining from swimming, and plan off-season training schedules accordingly to allow for adequate rest/recovery and prevent overuse injuries.

Lo et al., (2011) examined the training and detraining effects of the resistance vs. endurance program on body composition, body size, and physical performance in young men. Thirty healthy college men (20.4 ± 1.36 years) participated in the study. Subjects were assigned to resistance training group

(RTG, n = 10), endurance training group (ETG, n = 10), and control group (CG, n = 10). The conclusions of their study are (a) that endurance or resistance training alone led to training-specific improvements in physical performance, body composition, and body size of the arms for the young men and (b) that the RTG maintained the gains in strength and LM for more prolonged periods after training ceased than the endurance training group.

Lobo**,** Carvalho and Santos (2010) assessed the effects of different strategies of health on the levels of physical activity (PA), physical fitness (PF), cardiovascular disease (CVD) risk factors and quality of life (QoL) of the institutionalized elderly. Concurrently studies were made of the effect of detraining on these same variables. In this investigation they carried out a prospective longitudinal study with an experimental design, with 1 year plus 3 months of a detraining period. (a) A questionnaire with socio-demographic characteristics and a QoL scale (MOS SF-36); (b) Functional Fitness Test to assess PF; (c) An MTI Actigraph to evaluate the PA; (d) Biochemical analysis of blood, blood pressure and bio-impedance. The main results indicated that: (i) ST significantly improved strength and body flexibility and AT the aerobic endurance, agility/dynamic balance and lower strength and flexibility; (ii) Implications of detraining were more evident on the PA groups in the lower body flexibility, which is associated with agility/dynamic balance and lower strength in the AT group; (iii) Cardiovascular variables improved significantly especially blood pressure, cholesterol and glucose in the ST and HDL in the AT group; not having undergone significant changes with the detraining. The

results of this thesis contribute positively to highlight the importance of PA in the promotion of health, prevention and reduction of CVD risk factors and the improvement of the PF and QoL.

Carvalho et al., (2009) investigated the Training and detraining effects on functional fitness after a multi component training in older women. Eight month multi component training and 3-month detraining on the functional fitness was given to older women. Fifty-seven women were randomly assigned to an exercise (n = 32; 68.4 +/- 2.93 years) or a control group (n = 25; 69.6 +/- 4.20 years). The training program consisted of 2 sessions per week of aerobic, strength, balance and flexibility exercises. The results of this study highlight both upper and lower body strength and upper and lower flexibility declined significantly after detraining in the exercise group.

Tokmakidis, Spassis and Volaklis (2008) investigated the adaptations of a water-based training program as well as the detraining and retraining effects on physiological parameters in patients with coronary artery disease (CAD). Twenty-one patients were separated in an exercise group (n = 11) and a control group (n = 10). The exercise group followed three periods: training, detraining and retraining. Each period lasted 4 months. During the training and the retraining periods, the patients performed four sessions of water exercise (not swimming) per week. The water-based program was well-accepted and no adverse effects were observed. The exercise group improved ($p < 0.05$) their stress-test time (+11.8%), VO(2 peak) (+8.4%) and total body strength (+12.2%) after the training period; detraining tended to reverse these positive

adaptations. Resumption of training increased the beneficial effects obtained after the initial training period (exercise stress: +4.5%; VO(2 peak): +6.6%; total strength: +7.0%). The patients in the control group did not show any significant alterations throughout the study. Water-based exercise is safe and induces positive physiological and muscular adaptations in low-risk patients with CAD. These could be reversed, however, after the cessation of exercise. This is why uninterrupted exercise throughout life is a must.

Liu et al., (2008) investigated the effects of short-term detraining on measures of obesity and glucose tolerance in elite athletes. Sixteen elite kayak athletes were randomly assigned to a totally detrained group (age: 20.8 years; body mass index: 23.74) or partially detrained group (age: 21.8 years; body mass index: 23.20). Waist circumferences for both the partially detrained and totally detrained groups were significantly elevated after detraining, with no group difference. However, body mass was reduced in both groups. These changes were greater in the totally detrained participants. They concluded that maintaining partial training activity cannot prevent an increase in waist circumference.

Gamelin et al., (2007) investigated the effect of twelve weeks of aerobic training and eight weeks of training cessation on Heart Rate Variability (HRV). Ten healthy young men (Age: 21.7 ± 2.2 years; Height: 179.2 ± 6.9 cm; Mass 72.7 ± 11.1 kg) completed an incremental test and a 608 tilt test during which R-R intervals were recorded before (T0) and after (T12) 12 weeks of intensive training, and after 2, 4 and 8 weeks of training cessation (D2, D4 and D8,

respectively). HRV was computed in time and frequency domains. Training resulted in a significant increase in estimated V˙ O2max after T12 ($p < 0.01$), followed by a significant decrease during D2 and D8 ($p < 0.05$). Total power (LF + HF) and low frequency power (LF) increased significantly in the supine position after the training period ($p < 0.05$) and decreased moderately after D2 ($p > 0.05$) to stabilize afterwards. LF + HF and LF were not different from T0 at D8 ($p > 0.05$). It was concluded that eight weeks of training cessation allow reversing the cardiovascular autonomic adaptations induced by 12 weeks of intensive training in healthy young men.

Slentz et al., (2007) studied the beneficial effects of exercise on lipoproteins. Sedentary, overweight subjects (n = 240) were randomized to 6-mo control or one of three exercise groups: 1) high-amount/vigorous-intensity exercise; 2) low-amount/vigorous-intensity exercise; or 3) low-amount/moderate-intensity exercise. Training consisted of a gradual increase in amount of exercise followed by 6 mo of exercise at the prescribed level. Exercise included treadmill, elliptical trainer, and stationary bicycle. The number of minutes necessary to expend the prescribed kilocalories per week (14 kcal x kg body wt(-1) x wk(-1) for both low-amount groups; 23 kcal x kg body wt(-1) x wk(-1) for high-amount group) was calculated for each subject. Average adherence was 83-92% for the three groups; minutes per week were 207, 125, and 203 and sessions per week were 3.6, 2.9, and 3.5 for high-amount/vigorous-intensity, low-amount/vigorous intensity, and low-amount/moderate-intensity groups, respectively. Plasma was obtained at

baseline, 24 h, 5 days, and 15 days after exercise cessation. Continued inactivity resulted in significant increases in low-density lipoprotein (LDL) particle number, small dense LDL, and LDL-cholesterol. A modest amount of exercise training prevented this deterioration. Moderate-intensity but not vigorous-intensity exercise resulted in a sustained reduction in very-low-density lipoprotein (VLDL)-triglycerides over 15 days of detraining ($P < 0.05$). The high-amount group had significant improvements in high-density lipoprotein (HDL)-cholesterol, HDL particle size, and large HDL levels that were sustained for 15 days after exercise stopped. In conclusion, physical inactivity has profound negative effects on lipoprotein metabolism. Modest exercise prevented this. Moderate-intensity but not vigorous-intensity exercise resulted in sustained VLDL-triglyceride lowering. Thirty minutes per day of vigorous exercise, like jogging, has sustained beneficial effects on HDL metabolism.

Volaklis (2006) assessed the training and detraining effects on physiological parameters resulting from a combined strength and aerobic exercise programme in patients with coronary artery disease. Thirty male coronary artery disease patients were randomly assigned to an exercise ($n = 16$) and control group ($n = 14$). Patients in the exercise group participated in a supervised exercise programme for 8 months and were followed for 3 months after training cessation. The programme consisted of two sessions of circuit weight training and two sessions of aerobic training. Cardiopulmonary testing and muscular strength were assessed at baseline and after 4 and 8 months of

training as well as after 3 months of detraining. The exercise training programme resulted in significant improvement in cardiorespiratory fitness (VO2peak 15.4% and exercise time 14%) after 8 months. Muscular strength also increased significantly in all exercises by an average of 28% (upper body 25.5% and lower body 35.4%). Three months of detraining, however, resulted in a 10% regression in VO2peak, 6.7% in exercise time, 12% in upper body strength and 15.7% in lower body strength of patients with coronary artery disease.

Ingle et al., (2006) examined the physical characteristics of the 54 male participants in the present study age 12.3 +/- 0.3 years, height 1.57 +/- 0.07 m. Participants were randomly assigned to an experimental (n = 33) or control group (n = 21). The training, which was performed three times a week for 12 weeks. After training, participants completed 12 weeks of detraining. They concluded, in pre- and early pubertal boys, Training is a time-effective and safe training modality that confers small improvements in anaerobic power and jumping, throwing and sprinting performance, and marked improvements in dynamic strength. However, after detraining, the benefits of complex training are lost at similar rates to other training modalities.

Petibois et al., (2004) described long-term detraining effects on lipid profile in previously highly endurance-trained athletes. The study design was longitudinal, with a 2-yr follow-up study of changes in lipid profile during hard training and detraining. Ten subjects trained for 2 yr (22 h/wk; two 47-wk training periods with a 5-wk recovery period), and the 10 others stopped

training after wk 47. Main blood lipid profile parameters, energy intake, and body composition were measured at baseline (wk 1) and at wk 24, 47, 52, 76, and 99. Although food caloric intake was reduced (2411 ± 256 *vs.* 5697 ± 455 kcal/d, detraining *vs.* training), detraining induced a decrease in high density lipoprotein cholesterol and increases in fat mass (by 6.5 ± 1.1 kg), body mass index, leptin, low density lipoprotein cholesterol, low density lipoprotein/high density lipoprotein ratio, and apolipoprotein B, although insulin resistance (determined by homeostasis model assessment) stabilization had previously occurred. Further disorders appeared in triglycerides (TG) metabolism during detraining, with a persistent increase in TG (from 1.0 ± 0.3 to 1.4 ± 0.3 mmol/liter), whereas glycerol decreased (from 88 ± 9 to 73 ± 8 μmol/liter), and very low density lipoprotein-TG, chylomicrons, and apolipoprotein C_3 remained stable. Plasma lipoprotein lipase activity decreased whereas hepatic lipase activity remained stable. As well as a rapid loss of endurance-training benefits for the cholesterolemic profile, detraining also induced disorders in TG metabolism, possibly as a result of the elevated TG turnover acquired with long-term hard training.

Tokmakidis and Volaklis (2003) investigated the training and detraining effects on blood lipids and apolipoproteins induced by a specific program that combined strength and aerobic exercise in patients with coronary artery disease (CAD). For this study, 14 patients participated in a supervised 8-month training program composed of two strength sessions (60% of 1 repetition maximum) and two aerobic training sessions (60%-85% of maximum heart rate), and 13

patients served as a control group. Blood samples for total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), apolipoproteins A1 (apo-A1) and B (apo-B), and lipoprotein (a) (Lp[a]) were obtained along with muscular strength at the beginning of the study, after 4 and 8 months of training and after 3 months of detraining. The patients in the intervention group showed favorable alterations after 8 months of training (TC, -9.4; TG, -18.6; HDL-C, 5.2; apo-A1, 11.2%; P <.05), but these were reversed after 3 months of detraining (TC, +3.7; TG, 16.1; HDL-C, -3.6; apo-A1, -5.5%). In addition, body strength also improved after training (27.8%) but reversed (-12.9%) after detraining (P <.05). The patients in the control group did not experience any significant alterations.

LeMura et al., (2000) evaluated the effects of various modes of training on the time-course of changes in lipoprotein-lipid profiles in the blood, cardiovascular fitness, and body composition after 16 weeks of training and 6 weeks of detraining in young women. A group of 48 sedentary but healthy women [mean age 20.4 (SD 1) years] were matched and randomly placed into a control group (CG, n = 12), an aerobic training group (ATG, n = 12), a resistance training group (RTG, n = 12), or a cross-training group that combined both aerobic and resistance training (XTG, n = 12). The ATG, RTG and XTG trained for 16 weeks and were monitored for changes in blood concentrations of lipoprotein-lipids, cardiovascular fitness, body composition, and dietary composition throughout a 16 week period of training and 6 weeks of detraining. The ATG significantly reduced blood concentrations of

triglycerides (TRI) ($P < 0.05$) and significantly increased blood concentrations of high-density lipoprotein-cholesterol (HDL-C) after 16 weeks of training. The correlation between percentage fat and HDL-C was 0.63 ($P < 0.05$), which explained 40% of the variation in HDL-C, while the correlation between maximal oxygen uptake (VO2max) and HDL-C was 0.48 ($P < 0.05$), which explained 23% of the variation in HDL-C. The ATG increased VO2max by 25% ($P < 0.001$) and decreased percentage body fat by 13% ($P < 0.05$) after 16 weeks. Each of the alterations in the ATG had disappeared after the 6 week detraining period. The concentration of total cholesterol (TC), TRI, HDL-C and low density lipoprotein-cholesterol in the blood did not change during the study in RTG, XTG and CG. The RTG increased upper and lower body strength by 29% ($P < 0.001$) and 38%, respectively. The 6 week detraining strength values obtained in RTG were significantly greater than those obtained at baseline. The XTG increased upper and lower body strength by 19% ($P < 0.01$) and 25% ($P < 0.001$), respectively. The 6 week detraining strength values obtained in XTG were significantly greater than those obtained at baseline. The RTG, XTG and CG did not demonstrate any significant changes in either VO2max, or body composition during the training and detraining periods. The results of this study suggest that aerobic-type exercise improves lipoprotein-lipid profiles, cardiorespiratory fitness and body composition in healthy, young women, while resistance training significantly improved upper and lower body strength only.

Mujika et al., (2000) examined the physiological and performance responses to a 6-d taper, and the influence of training intensity and volume on these responses. After 15 week of training, 8 well-trained male middle-distance runners were randomly assigned to either a moderate volume taper (MVT, N = 4) or a low volume taper (LVT, N = 4), consisting of either a 50% or a 75% progressive reduction in pre-taper low intensity continuous training (LICT) and high intensity interval training (HIIT). Blood samples were obtained and 800-m running performance was measured before and after taper. They found that the performance was not significantly enhanced by either taper protocol. They concluded that taper-induced physiological changes in trained middle-distance runners are mainly hematological, and that distinct physiological changes are elicited from low intensity continuous training and high intensity interval training during taper. Middle-distance runners can progressively reduce their usual training volume by at least 75% during a 6-d taper.

Motoyama et al., (1995) studied the effect of long-term low intensity aerobic training and detraining on serum lipid and lipoprotein concentrations was examined in 30 elderly men and women. These subjects were randomly divided into two groups. The training group [*n*=15; 7 men and 8 women; mean age 75.5 (SD 5.6) years] agreed to take part in physical training using a treadmill with an exercise intensity at the blood lactate concentration threshold for 30 min 3–6 times a week for 9 months. The other group [*n*=15; 7 men and 8 women; mean age 73.7 (SD 4.4) years] did not perform any particular physical training and was followed as the control. Following this training period the

high density lipoprotein-cholesterol (HDL-C) had increased significantly (P<0.01) while the total cholesterol (TC) : HDL-C ratio had decreased significantly (P<0.01) in the training group after 9 months but had not changed in the control group. The TC, triglyceride (TG) and low density lipoprotein-cholesterol (LDL-C) had not changed significantly in either group. No significant difference was seen between the groups throughout the period for TC, LDLC or TG. There was, however, a significant correlation between the initial TC:HDL-C ratio and the change in the TC:HDL-C ratio following 3 months of training (P <0.05). After 1 month of detraining in 5 patients, the HDL-C had decreased significantly (P < 0.05) while the TC:HDL-C had increased significantly in the training group (P<0.01). These results suggested that long-term low intensity aerobic training improved the profile of serum lipid and lipoprotein concentrations, while detraining returned the profile to that of the pre-training levels in elderly persons.

2.3: Summary of the Literatures

According to literature to date, the basic physical fitness components physiological and body composition variables are altered after resistance training. There is a substantial amount of evidence that resistance training has a positive effect on gains of physical fitness components physiological and body composition variables. One conclusion that can be drawn is that athletes who are solely concerned with strength and power should probably keep their endurance training to a minimum. Another conclusion that can be made based on the literature examined the effects resistance training had on endurance

performance if an endurance athlete adds resistance training probably have a positive effect on their performance. All athletes would be best advised to follow the principle of specificity, which means training that is specific to the types of movements and energy systems used in their respective sports. For the average person who is training for health benefits, performing resistance training is probably the best way to improve their physical fitness from a cardiovascular and muscular standpoint.

It has been observed that the adaptation of physical fitness components physiological and body composition variables due to the resistance training from some of the research findings. Research examining these types of training would allow the organizations and individuals that prescribe exercise around the world to better understand the consequences of prescribing resistance training.

Several different types of studies have been conducted examining the effects of resistance training. Some studies have examined whether or not resistance training produces different results than either strength or endurance training alone. Other studies have investigated the effects of adding resistance training to the training regime of endurance-trained athletes. These studies have examined how endurance performance was affected. The studies are often similar in some aspects of their design but are very different in others. The breakdown of subject training groups is almost identical for all studies. Most studies include an endurance training only group, a resistance training only

group, and a combined training group. Some studies have included a control group.

By studying the related literature, the investigator arrives at the conclusion that there are different views with regard to resistance training on physical fitness components physiological and body composition variables and its implications in various sports and situations. Some studies revealed that there is significant difference between isolated and combined training with regard to these characteristics in sports. Research in the field of resistance training and detraining on physical fitness components, physiological and body composition variables of kabaddi players appears to be limited, as it does not focus on the young players. Therefore, it is necessary to know the actual result regarding the resistance training and its relationship with sports performance particularly in kabaddi. India always excelled in kabaddi and quite a few researchers analysed various factors associated with kabaddi performance. Hence, the present study was conducted to determine significance improvement in various physical fitness components, physiological and body composition variables due to resistance training.

Most of the training benefits are lost within a relatively short period of time after cessation of physical training has been found in earlier studies. However majority of these studies have been performed apparently among aerobic fitness components. Additionally, these studies have mostly been done in hormonal, metabolic and enzyme responses to detraining. It has been observed that the metabolic, structural and performance adaptation from

resistance training programme are reduced with short-term detraining. Data on the impact of detraining on physical fitness components, physiological and body composition variables is especially scarce. Few studies have been done to address the general statements of the benefits and adverse effects of resistance training and detraining among players. However, the overall effects of resistance training and detraining impact on physical fitness components, physiological and body composition variables among kabaddi players have to be investigated as the scientific literature available is inconclusively documented.

In this chapter, the researcher had given research abstracts, which has been conducted recently and published through magazines, journals and periodicals pertaining to the topic considered in this study. These reviews of related literature helped the researcher for the better understanding of the problem and to interpret the result.

Chapter III

METHODOLOGY

3.1: Over view

Research methodology involves the systematic procedure by which the research starts from the initial identification of the problem to its final conclusions. The role of the methodology is to carry on the research work in a scientific and valid manner.

In this chapter, procedures and methods applied for selection of subjects, selection of variables, selection of tests, competence of the tester, instruments reliability, reliability of the data, orientation to the subjects, pilot study, training protocol, collection of the data, administration of the tests and statistical techniques were presented.

3.2: Selection of the Subjects

Thirty male inter-collegiate kabaddi players volunteered to participate in the study. The selected participants were studying in various arts and science colleges affiliated to Manonmanium Sundaranar University, from kanyakumari district, India during the academic year 2016-2017. Their age ranged from 18 years to 22 years. They were randomly divided into two groups and each group consisted of fifteen participants. A written consent form was signed by all participants after they had been informed of all risks, discomforts, and benefits involved. The copy of the consent form is enclosed in appendix –I.

3.3: Selection of Variables

The researcher had gone through the available literature and had discussions with various experts and with his guide before selecting variables. The availability of technique for the purpose of analysis, feasibility, reliability of the procedure and the outcome were extensively taken care before finalizing the variables.

3.3.1: Dependent Variables

Physical fitness emphasizes the development of those qualities that enhance the performance of physical activities such as sport. Whereas health fitness was concerned with living better, motor performance fitness is concerned with skills better and more efficiently. Moreover, physical fitness is specific to the sport or activity in which the individual engages. Different combinations of motor performance fitness components are needed, depending on the specific motor activity.

The human body consists of several components including fat mass, lean muscle mass, skeletal bone mass and total body water. The proportions of each of these components have important implications for present and future health outcomes including cardiovascular, nutritional and psychological status as well as physical performance capability. Body composition assessment has revealed that athletes generally have physique characteristics unique to their specific sports. For example, field events athletes have large quantities of lean tissue and a high percent body fat whereas long distance runners have the least amount of lean body and fat weight. Now a day's body composition is

considered one of the components of fitness as it plays important role in developing fitness.

The physiological basis of this principle rests on the fact that as a result of training, the body's functional efficiency and their by, its capacity to work, gradually increase over a long period of time. Similarly, any drastic increase in one's performance requires a long period of training and adaptation. Since, the physical fitness, physiological and body composition parameters are the determinant in almost all games and sports, the following dependent variables were selected for this study.

Physical Fitness Components

- Muscular strength
- Explosive power

Physiological Parameters

- Resting Heart Rate
- Maximum oxygen consumption

Body Composition Variables

- Percent body fat
- Body mass index

3.3.2: Independent Variable

The experimental variables used in the present study was resistance training. Though many methods prevail to develop physical fitness, physiological and body composition parameters, the role of resistance training is an undisputed one, lot of researches had been carried out on the effects of

resistance training, but still the bone of contention is about the duration to get the maximum benefit. In this context, the investigator makes an attempt to analyse the effect of resistance training on physical fitness, physiological and body composition parameters.

There is clear evidence that the use of resistance training is one of the effective training method to improve the selected criterion variables. The current study created a resistance training programme to determine its effectiveness as a tool for selected variables among kabaddi players. Resistance training has been found to elicit greater change in selected physical, physiological and body composition variables.

Most athletes in team sports go into physical hibernation following the completion of their competitive season. In such case the training benefits are lost within a relatively short period of time, after the training being stopped. Few studies have been done to address the general statements of the benefits and adverse effects of resistance training and detraining among kabaddi players. However, the overall effects of resistance training and detraining impact on physical fitness, physiological and body composition parameters among untrained men have to be investigated as the scientific literature available is inconclusively documented. Hence, the researcher was selected resistance training as independent variable for this study.

3.4: Selection of Tests

The selected physical fitness, physiological and body composition parameters and their respective tests are presented in table-I.

Table – I

Selection of Dependent Variables and Tests

S. No	Dependent Variables	Instruments/ Test/Method/	Unit of Measurements
Physical Fitness Components			
1	Muscular strength	1 RM (Bench Press)	Kg
2	Explosive power	Standing broad jump	Meters
Physiological Parameters			
3	Resting heart rate	Digital blood pressure monitor	bpm
4	Vo_2max	1 Mile Run	ml/kg/min
Body Composition Variables			
5	Percent body fat	Skin fold Calliper $= \left[\frac{4.950}{\text{Density}} - 4.500 \right] \times 100$	Percentage
6	Body mass index	$= \frac{\text{wt}}{\text{Ht}^2}$	Kg/m^2

3.5: Reliability of the Instrument

The required instruments such as measuring tape, weighting machine, skin fold calibre, stop watch and digital blood presser monitor were taken from the Christian College of Physical Education, Nagercoil. The instruments were purchased from the standardized companies. Their calibrations were tested and found to be accurate enough to serve the purpose of the study.

3.6: Reliability of the Data

To establish the reliability of the data, test and re-test method was adopted. The selected criterion variables in the present study were tested twice under the similar condition. The intra class co-efficient of correlation was used to find out the reliability of the data and the obtained results are presented in table –II.

Table – II

Intra Class Co-Efficient of Correlation on Selected Dependent Variables

S. No.	Dependent Variables	'R' Value
1	Muscular strength	0.93*
2	Explosive power	0.90*
3	Resting heart rate	0.88*
4	Vo_2max	0.92*
5	Percent body fat	0.96*
6	Body mass index	0.95*

**Significant at 0.05 level of confidence.*
Table value require for significance at 0.05 level of confidence is 0.76

Since the obtained 'r' values were much higher than the required table value, the data were accepted as reliable in terms of instrument, tester and the subjects.

3.7: Orientation to the Subjects

The director of physical education of the conceder colleges from Kanyakumari district were contacted by prior appointment and had a discussion about the purpose of the study as well as the importance, nature, application and nature of information required for the study. Then the director of physical educations introduced the investigator to the coach of the kabaddi team through proper way. Then the coaches introduced corresponding sport persons to the investigator. The nature and purpose of the study were again explained to the coaches and the subjects. The subjects were sufficiently motivated to perform their maximal level during the testing period and assurance was given to each

subject that the information gathered from them would be used only or research purpose and that everything including their identity would be kept confidential.

3.8: Competency of the Tester

The investigator learned the procedures and methods to handle and operate the instruments to administer the test. Measurements were taken by the investigator himself using bio-monitor, stop watches and steel tape. Services of qualified assistants were used for taking other measurements.

3.9: Pilot Study

A pilot study was conducted to assess the initial capacity of the subjects to fix the load, select the exercises and to design the training programme. Ten men subjects were selected at random for this purpose, and they were given resistance training under the watchful eyes of the investigator. During the pilot study the subject's 1RM of each exercise was assessed. Based on the performance the initial load was fixed for the subjects. While constructing the training programmes the basic principles of sports training progression of load and specificity were followed. During construction of the training programme, the individual differences were also being considered.

3.10: Training Programme

The experimental group performed both the resistance training programs three sessions per week on alternative days for 12 weeks. The resistance training program was a total body workout consisting of 3 sets of 6-10 repetitions on 5 exercises that trained all the major muscle groups. A percentage of each subject's one-repetition maximum for each exercise was

used to determine the intensity of each week. The intensity and number of repetitions performed for each exercise was progressively increased.

The subjects of the experimental group- I performed the following resistance training exercises namely power clean, leg press, bench press, heel raise, abdominal crunches, lat pull down, hamstring curl and deep squat respectively.

Week		**I & II**		**III & IV**		**V & VI**		**VII & VIII**		**IX & X**		**XI & XII**	
Intensity		70%		75%		80%		85%		90%		95%	
Recovery between Exercise		1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1
Recovery between Set		1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3
Monday	Repetition	10		9		8		7		6		5	
	Set	3		3		3		3		3		3	
Wednesday	Repetition	11		10		9		8		7		6	
	Set	3		3		3		3		3		3	
Friday	Repetition	12		11		10		9		8		7	
	Set	3		3		3		3		3		3	

3.11: Detraining Programme

After the completion of twelve weeks of resistance training the subjects of both the experimental and control groups were physically detrained for 30 days. During this period the subjects were instructed not to participate in any strenuous physical activity.

3.12: Collection of the Data

The pretest and posttest data were collected prior to and immediately after the twelve week of resistance training programme from both the experimental and control groups. During the detraining period the data were collected for all the selected criterion variables once in ten days for 30 days (*three cessations*) from the experimental and control groups. All the tests were conducted on the same day.

3.13: Administration of the Tests

3.13.1: Bench Press

Purpose: To measure muscular strength

Equipments: Bench with safety, bar and various free weights plates.

Procedure: The subjects assumed a supine position on the bench, the feet must be placed on the floor, and two assistants placed the bar in the hands and across the chest. With the hands approximately shoulder width apart; the performer extended the arms, the weight was lifted upward until the arms were fully extended and then lowered until the weight s touched the weight beneath them. After a successful lifted the subjects were to rest 2 to 3 minutes. The weight was increased by one or two kg after every successful lift. The same patterns are continued until the subjects could no more execute a successful trial.

Scoring: The maximum weight lifted by the subjects was measures in kilograms and considered scores.

3.13.2: Standing Broad Jump

Purpose: The purpose of the test was to measure the explosive power in horizontal distance.

Equipment: Measuring tape and Chunnam.

Procedure: A take off line is drawn on the ground. The subject takes a position with toes just behind the take off line, feet slightly apart. Taking off from both feet simultaneously then jumps as far as possible and landing on both feet. In jumping, the subject crouches slightly and swings the arms to aid the jump.

Scoring: The score is the distance to the nearest centimetre from take off line to the closest heel position. The best of 3 trails is recorded (Jenson & Hirst, 1980).

3.13.3: Resting Heart Rate

Purpose: To measure the number of pulse per minute.

Equipment: Digital blood pressure monitor was used to observe the radial artery pulse.

Procedure: The pulse was measured at the wrist, by winding up the wristlet cuff of the digital blood pressure monitor – wrist measuring model Ch 607 from citizen systems Japan, around the left wrist, by placing the body of the blood pressure monitor on the inside of the wrist. The measurement was taken while at sitting position and with the left hand on a table held a level with the heart, keep the body still and relaxed during measurement.

Scoring: The number of pulse per minute was recorded as shown in the digital blood pressure monitor.

3.13.4: One Mile Run/Walk Test

Purpose: The purpose of this test was to measure the Vo_2max of the subjects.

Equipment: Stop watch, sphygmomanometer and stethoscope and weighing machine.

Procedure: The procedure recommended by Kline et al., (1987) was used. The exact age of the subject was found from the college records. The weight of the subject was measured with minimum cloths and without shoes in kilograms and then converted into pounds. The one mile run was conducted at the standard 400 m track. All the subjects were given instructions regarding the procedure and asked to complete the 1 mile distance at their optimum speed. One testing assistant was assigned per subject. On the command 'go' all the subject started their run/walk. The assistants instructed to each subject about their distance (laps) covered and verbally motivated them.

Scoring: At the end of the 1 mile run/walk the time taken for each individual was noted in minutes and the testing assistants measured the heart rate of their corresponding subjects. The values were expressed in L/min.

The Vo_2max was estimated using the formula.

$$Vo_2 = 6.9652 + (0.0091 \times \text{weight}) - (0.0257 \times \text{Age}) + (0.5955 \times \text{Sex}) - (0.2240 \times T) - (0.0115 \times H.R).$$

Weight = in pounds

Age = in years

Sex = 1 for male

T = Time taken for 1 mile run/walk in minutes

HR = Heart rate at the end of the 1 mile run/walk.

3.13.5: Percent Body Fat

Purpose: To measure the percent body fat of the subjects

Equipment: Skinfold calliper and score sheet.

Procedure: The subject was asked to stand erect. The skin fold measurements were taken of three sites namely triceps, subscapular and abdominal. The skin fold was grasped between the thumb and index finger about one centimetre from the site at which calliper was to be applied above the finger holding the skin fold.

Scoring: All measurements were made to the nearest millimetre. The percent body fat was found out by applying the formula of Brozek (1971). % Body fat = 457/Bd – 414.2/Bd is calculated by using Lohman (1981)/ formula Bd= 1.0982-(.000815) (X) + (.00000084) (X^2)/ where X=the sum of triceps, subscapular and abdominal skin fold.

3.13.6: Body Mass Index

Purpose: To measure the change ratio of the subject.

Equipments: Stadiometer, Weighing machine and score sheet.

Procedure: The subjects stand erect on the floor board of the stadiometer with his back to the vertical backboard of the stadiometer. The bar is locked in place on the head of the subject, so that the standing height measurement can be read on the tape. The subject to be weighed wearing a minimum amount of clothing,

such as only gym shorts, the subjects was weighted at the same time of the day and to the same degree of accuracy usually the nearest half kilogram. And the weighing scale should be in the kilogram mode.

Scoring: The reading of the height measurement was taken in nearest centimetre, and weight measurement was taken in kilograms.

$$BMI = \frac{\text{Weight (kg)}}{\text{Height (metres)}^2} \text{ kg/m}^2$$

3.14: Statistical Technique

The data collected from the two groups prior to and post experimentation were statistically analyzed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). The data collected from the two groups during post experimentation and detraining (three cessation) were statistically analyzed by using two way (2 x 4) factorial ANOVA with last factor repeated measures. If the obtained 'F' ratio for interaction effect was found to be significant, the simple effect test was used as a follow up test. Since, two groups and four different stages of test were compared, when the obtained 'F' ratio value in the simple effect test was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases statistical significance was fixed at .05 levels.

Chapter IV

ANALYSIS OF THE DATA AND RESULTS OF THE STUDY

4.1: Over View

The purpose of the study was to find out the effect of resistance training and detraining on physical fitness, physiological parameters and body composition variables. To achieve the purpose of this study, thirty male inter-collegiate kabaddi players volunteered to participate in the study. The selected participants were studying in various arts and science colleges affiliated to Manonmanium Sundaranar University, from kanyakumari district, India during the academic year 2016-2017. Their age ranged from 18 years to 22 years. They were randomly divided into two groups and each group consisted of fifteen participants. Group – I performed resistance training and group – II acted as control who did not participate in any specific training programmes.

The subjects were tested on the following variables such as, muscular strength, explosive power, resting heart rate, Vo_2 max, percent body fat and body mass index. The test conducted for two groups prior to and post experimentation and detraining (three cessation) once in ten days. The selected dependent variable muscular strength was measured by 1 RM bench press, explosive power was measured by standing broad jump, resting heart rate was assessed by digital blood pressure monitor, Vo_2 max was assessed by 1 mile run test, percent body fat was measured by skin fold calibre, body mass index was calculated by weight/height meter^2.

The data collected from the two groups prior to and post experimentation were statistically analyzed by applying the analysis of covariance (ANCOVA). The data collected from the two groups on prior and post experimentation and detraining (three cessation) were statistically analysed by using two way (2 x 4) factorial ANOVA with last factor repeated measures. If the obtained 'F' ratio for interaction effect was found to be significant, the simple effect test was used as a follow up test. Since, two groups and four different stages of test were compared, when the obtained 'F' ratio value in the simple effect test was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases statistical significance was fixed at .05 levels.

4.2: Analysis of Muscular Strength

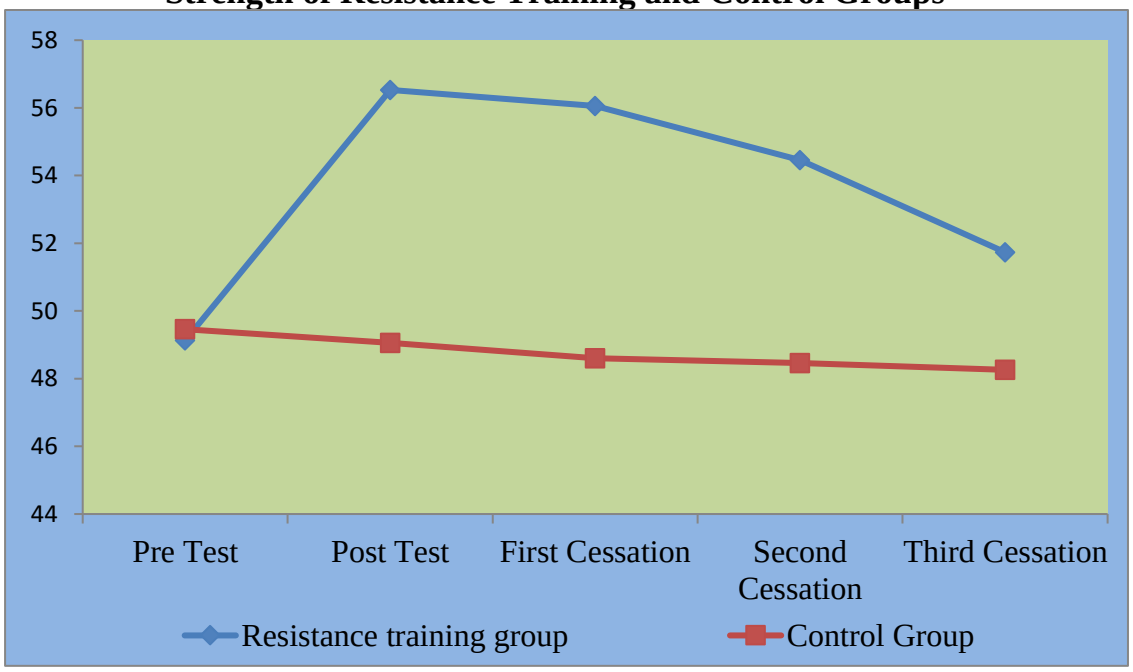
The mean and standard deviation values on muscular strength of resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.1.

Table – 4.1
The Pre, Post Test and Three Cessations Mean and Standard Deviation Values on Muscular Strength of Resistance Training and Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	49.13	56.53	56.06	54.46	51.73
	SD	1.41	1.12	1.16	1.8	0.88
Control Group	Mean	49.46	49.06	48.60	48.46	48.26
	SD	1.24	1.22	1.24	1.06	1.53

The pre test, post test, first, second and third cessation mean values on muscular strength of experimental and control groups are graphically represented in the figure – I.

Figure – I
Pre Test, Post Test And Three Cessation Mean Values on Muscular Strength of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on muscular strength were statistically analysed by ANCOVA and the results are presented in table 4.2.

Table 4.2
Analysis of Covariance on Muscular Strength of Resistance Training and Control Groups

	Resistance training group	Control Group	SoV	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean	49.13	49.46	B	0.83	1	0.83	0.47
SD	1.41	1.24	W	49.46	28	1.76	
Post test Mean	56.53	49.06	B	418.13	1	418.13	302.78*
SD	1.12	1.22	W	38.66	28	1.38	
Adjusted Post test Mean	56.52	49.07	B	410.06	1	410.06	286.69*
			W	38.61	27	1.43	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.2 shows that the pre-test mean and standard deviation on muscular strength of resistance training and control groups are 49.13 $\pm$ 1.41 and 49.46 $\pm$ 1.24 respectively. The obtained 'F' ratio value of 0.47 for pre test means on muscular strength of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on muscular strength of resistance training and control groups are 56.53 $\pm$ 1.12 and 49.06 $\pm$ 1.22 respectively. The obtained 'F' ratio value of 302.78 for post test means on muscular strength of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on muscular strength of resistance training and control groups are 56.52 and 49.07 respectively. The obtained 'F' ratio value of 286.69 for adjusted post test mean on muscular strength of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the muscular strength of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on muscular strength have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.3.

Table 4.3

Two Factor ANOVA on Muscular Strength of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	128.81	1	128.81	67.43*
Group Error	53.58	28	1.91	
B factor (Tests)	136.36	3	45.45	39.52*
AB factor (Interaction) (Groups and Tests)	80.10	3	26.70	23.22*
Error	96.53	84	1.15	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table- 4.3 shows that the obtained 'F' ratio for factor A (Groups) is 67.43 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the

study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on muscular strength.

Table - 4.3 also shows that the obtained ‘F’ ratio for factor B (Different stages of tests) is 39.52 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that, muscular strength differs significantly among different stages of testing irrespectively of groups.

Table - 4.3 also shows that the obtained ‘F’ ratio value of Interaction A x B (Groups x Different Tests) is 23.22 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. It shows that significant difference exist between groups at each test and also between tests for each group on muscular strength.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on muscular strength. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.4.

Table – 4.4

The Simple Effect Scores of Groups (Rows) at Five Different Stages of Tests (Columns) on Muscular Strength

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	418.13	1	418.13	363.59*
Groups at First Cessation	416.16	1	416.16	361.87*
Groups at Second Cessation	271.41	1	271.41	236.01*
Groups at Third Cessation	90.95	1	90.95	79.08*
Tests and Group I	211.26	3	70.42	61.23*
Tests and Group II	5.20	3	1.62	1.41
Error	96.53	84	1.15	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table- 4.4 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 363.59, 361.87, 236.01 and 79.08 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance. It indicates that significant difference exists between the paired means of groups at post test, first cessation, second cessation and third cessation on muscular strength.

Table 4.4 also shows that 'F' values obtained for tests and group-I is 61.23 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 1.41 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. It indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on muscular strength.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.5.

Table – 4.5
Scheffe's Test for the Differences among Paired Means of Resistance Training Group With Different Tests on Muscular Strength

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
56.53	56.06			0.47	0.79
56.53		54.46		2.07*	0.79
56.53			51.73	4.80*	0.79
	56.06	54.46		1.60*	0.79
	56.06		51.73	56.06*	0.79
		54.46	51.73	2.73*	0.79

**Significant at .05 level of confidence*

Table-4.5 shows that the mean differences between post test and second cessation, post test and third cessation, first and second cessation, first cessation and third cessation, second cessation and third cessation of resistance training group are 2.07, 4.80, 1.60, 56.06 and 2.73 respectively, which are higher than the confidence interval value 0.79. However the mean difference between post test and first cessation is 0.47 respectively on muscular strength which are lower than the confidence interval value of 0.79.

Hence it was concluded that the improved muscular strength performance of the participants were sustained only for 10 days during determining period, there after it was started decline towards the base line.

4.3: Analysis of Explosive Power

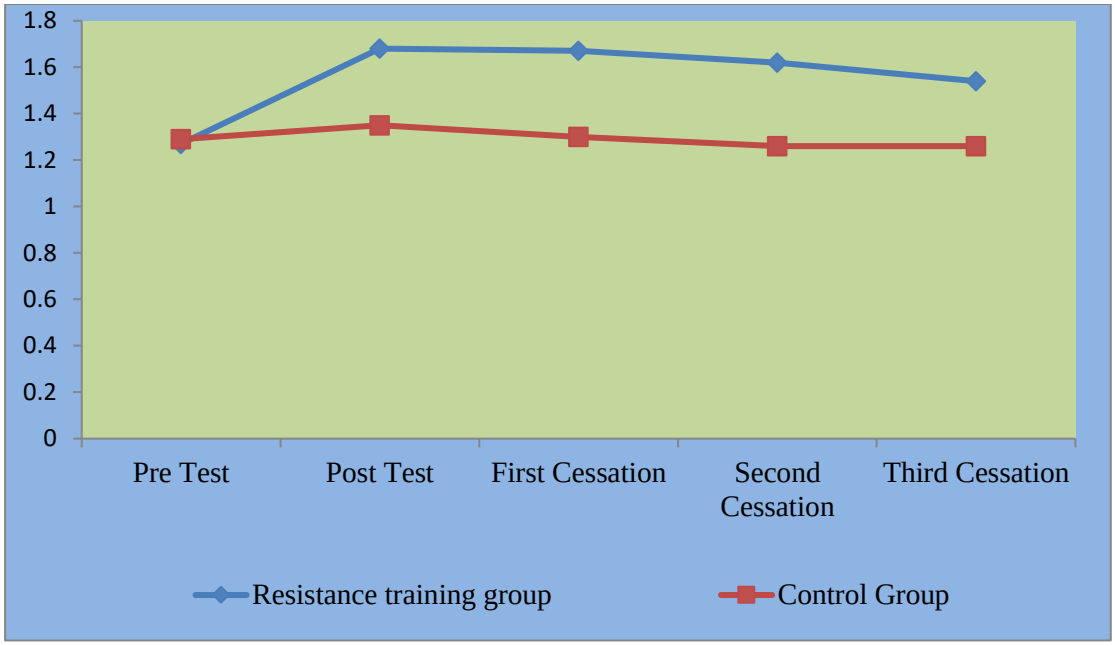
The mean and standard deviation values on explosive power resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.6.

Table – 4.6
The Pre, Post Test and Three Cessations Mean and Standard Deviation Values on Explosive Power of Resistance Training and Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	1.27	1.68	1.67	1.62	1.54
	SD	1.30	0.06	0.06	0.05	0.06
Control Group	Mean	1.29	1.35	1.30	1.26	1.26
	SD	1.20	0.18	0.40	0.36	0.36

The pre test, post test, first, second and third cessation mean values of experimental and control groups on explosive power are graphically represented in the figure – II.

Figure – II
Pre Test, Post Test and Three Cessation Mean Values on Explosive Power of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on explosive power were statistically analysed by ANCOVA and the results are presented in table 4.7.

Table 4.7
Analysis of Covariance on Explosive Power of Resistance Training and Control Groups

	Resistance training group	Control Group	SoV	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean SD	1.27	1.29	B	0.004	1	0.004	0.62
	1.30	1.20	W	0.44	28	0.016	
Post test Mean SD	1.68	1.35	B	0.83	1	0.83	42.02*
	0.06	0.18	W	0.55	28	0.02	
Adjusted Post test Mean	1.68	1.35	B	0.84	1	0.84	42.32*
			W	0.54	27	0.02	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.7 shows that the pre-test mean and standard deviation on explosive power of resistance training and control groups are 1.27 $\pm$ 1.30 and

1.29 ± 1.20 respectively. The obtained 'F' ratio value of 0.62 for pre test means on explosive power of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on explosive power of resistance training and control groups are 1.68 ± 0.06 and 1.35 ± 0.18 respectively. The obtained 'F' ratio value of 42.02 for post test means on explosive power of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on explosive power of resistance training and control groups are 1.68 and 1.35 respectively. The obtained 'F' ratio value of 42.32 for adjusted post test mean on explosive power of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the explosive power of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on explosive power have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.8.

Table 4.8
Two Factor ANOVA on Explosive Power of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	3.35	1	3.35	28.91*
Group Error	3.248	28	0.116	
B factor (Tests)	0.82	3	0.27	6.66*
AB factor (Interaction) (Groups and Tests)	0.36	3	0.12	2.92*
Error	3.42	84	0.041	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table 4.8 shows that the obtained 'F' ratio for factor A (Groups) is 28.91 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on explosive power.

Table 4.8 also shows that the obtained 'F' ratio for factor B (Different stages of tests) is 6.66 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that, explosive power differs significantly among different stages of testing irrespectively of groups.

Table 4.8 also shows that the obtained 'F' ratio value of Interaction A x B (Groups x Different Tests) is 2.92 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of

confidence. The result of the study shows that significant difference exist between groups at each test and also between tests for each group on explosive power.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on explosive power. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.9.

Table – 4.9
The Simple Effect Scores of Groups (Rows) At Five Different Stages of Tests (Columns) on Explosive Power

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	0.83	1	0.83	20.24*
Groups at First Cessation	1.016	1	1.016	24.78*
Groups at Second Cessation	0.958	1	0.958	23.36*
Groups at Third Cessation	0.582	1	0.582	14.19*
Tests and Group I	0.185	3	0.185	4.51*
Tests and Group II	0.078	3	0.078	1.90
Error	3.42	84	0.041	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table 4.9 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 20.24, 24.78, 23.36 and 14.19 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that significant difference exists between the paired means of groups

at post test, first cessation, second cessation and third cessation on explosive power.

Table 4.9 also shows that 'F' values obtained for tests and group-I is 4.51 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 1.90 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. The result of the study indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on explosive power.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.10.

Table – 4.10
Scheffe's Test for the Differences among Paired Means of Resistance Training Group with Different Tests on Explosive Power

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
1.68	1.67			0.01	0.14
1.68		1.62		0.06	0.14
1.68			1.54	0.14*	0.14
	1.67	1.62		0.05	0.14
	1.67		1.54	0.13	0.14
		1.62	1.54	0.08	0.14

**Significant at .05 level of confidence*

Table 4.10 shows that the mean differences between post test and third cessation, of resistance training group is 0.14, which is higher than the confidence interval value 0.14. However the mean difference between post test

and first cessation, post test and second cessation, first and second cessation, first cessation and third cessation, second cessation and third cessation are 0.01, 0.06, 0.05, 0.13 and 0.08 respectively on explosive power which are lower than the confidence interval value of 0.14 at 0.05 level of confidence.

Hence it was concluded that the improved explosive power performance of the participants were sustained only for 10 days during determining period, there after it was started decline towards the base line.

4.4: Analysis of Resting Heart Rate

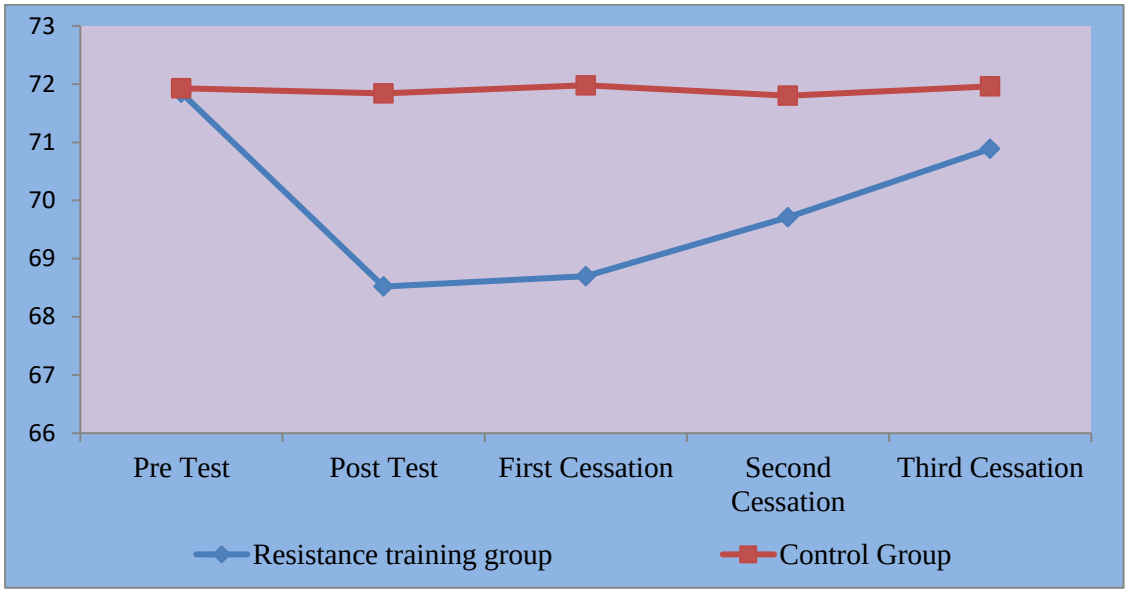
The mean and standard deviation values on resting heart rate resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.11.

Table – 4.11
The Pre, Post Test and Three Cessations Mean and Standard Deviation Values on Resting Heart Rate of Resistance Training and Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	71.85	68.52	68.70	69.71	70.89
	SD	0.63	0.60	0.55	0.61	0.77
Control Group	Mean	71.93	71.84	71.98	71.80	71.96
	SD	0.70	0.67	0.62	0.57	0.52

The pre test, post test, first, second and third cessation mean values of experimental and control groups on explosive power are graphically represented in the figure – III.

Figure – III
Pre Test, Post Test And Three Cessation Mean Values on Resting Heart Rate of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on resting heart rate were statistically analysed by ANCOVA and the results are presented in table 4.12.

Table 4.12
Analysis of Covariance on Resting Heart Rate of Resistance Training and Control Groups

	Resistance training group	Control Group	SoV	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean	71.85	71.93	B	0.05	1	0.05	0.11
SD	0.63	0.70	W	12.67	28	0.45	
Post test Mean	68.52	71.84	B	82.86	1	82.86	202.32*
SD	0.60	0.67	W	11.46	28	0.41	
Adjusted Post test Mean	68.51	71.85	B	0.34	1	0.34	202.07*
			W	83.21	27	83.21	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.12 shows that the pre-test mean and standard deviation on resting heart rate of resistance training and control groups are 71.85 ± 0.63 and 71.93 ± 0.70 respectively. The obtained 'F' ratio value of 0.11 for pre test means on resting heart rate of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on resting heart rate of resistance training and control groups are 68.52 ± 0.60 and 71.84 ± 0.67 respectively. The obtained 'F' ratio value of 202.32 for post test means on resting heart rate of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on resting heart rate of resistance training and control groups are 68.51 and 71.85 respectively. The obtained 'F' ratio value of 202.07 for adjusted post test mean on resting heart rate of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the resting heart rate of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on resting heart rate have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.13.

Table 4.13
Two Factor ANOVA on Resting Heart Rate
of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	25.87	1	25.87	66.48*
Group Error	10.89	28	0.38	
B factor (Tests)	27.81	3	9.27	24.59*
AB factor (Interaction) (Groups and Tests)	26.06	3	8.68	23.04*
Error	31.67	84	0.37	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table 4.13 shows that the obtained 'F' ratio for factor A (Groups) is 66.48 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on resting heart rate.

Table 4.13 also shows that the obtained 'F' ratio for factor B (Different stages of tests) is 24.59 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that, resting heart rate differs significantly among different stages of testing irrespectively of groups.

Table 4.13 also shows that the obtained 'F' ratio value of Interaction A x B (Groups x Different Tests) is 23.04 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study shows that significant difference exist

between groups at each test and also between tests for each group on resting heart rate.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on resting heart rate. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.14.

Table – 4.14
The Simple Effect Scores of Groups (Rows) at Five Different Stages of Tests (Columns) on Resting Heart Rate

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	82.86	1	82.86	223.94*
Groups at First Cessation	80.72	1	80.72	218.16*
Groups at Second Cessation	32.74	1	32.74	88.48*
Groups at Third Cessation	8.66	1	8.66	23.40*
Tests and Group I	53.54	3	53.54	144.70*
Tests and Group II	0.34	3	0.11	0.29
Error	31.67	84	0.37	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table 4.14 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 223.94, 218.16, 88.48 and 23.40 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that significant difference exists between the paired means of groups at post test, first cessation, second cessation and third cessation on resting heart rate.

Table 4.14 also shows that 'F' values obtained for tests and group-I is 144.70 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 0.29 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. The result of the study indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on resting heart rate.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.15.

Table – 4.15

Scheffe's Test for the Differences among Paired Means of Resistance Training Group with Different Tests on Resting Heart Rate

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
68.52	68.70			0.18	0.45
68.52		69.71		1.19*	0.45
68.52			70.89	2.37*	0.45
	68.70	69.71		1.01*	0.45
	68.70		70.89	2.19*	0.45
		69.71	70.89	1.18*	0.45

**Significant at .05 level of confidence*

Table 4.15 shows that the mean differences between post test and second cessation, post test and third cessation, first and second cessation, first cessation and third cessation, second cessation and third cessation of resistance training group are 1.19, 2.37, 1.01 and 2.19 respectively, which are higher than

the confidence interval value 0.45. However the mean difference between post test and first cessation is 0.18 respectively on resting heart rate which are lower than the confidence interval value of 0.45 at 0.05 level of confidence.

Hence it was concluded that the decreased resting heart rate performance of the participants were sustained only for 10 days during determining period, there after it was started incline towards the base line.

4.5: Analysis of Maximum Oxygen Consumption

The mean and standard deviation values on VO_2max of resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.16.

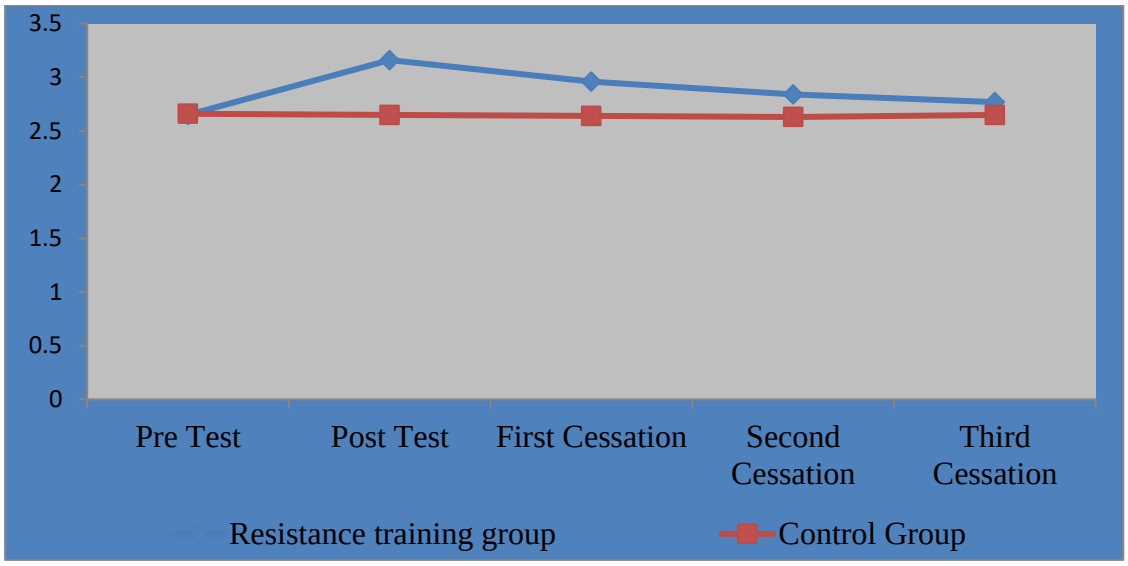
Table – 4.16

The Pre, Post Test And Three Cessations Mean And Standard Deviation On Vo_2 Max Of Of Resistance Training And Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	2.65	3.16	2.96	2.84	2.77
	SD	0.17	0.18	0.22	0.14	0.14
Control Group	Mean	2.66	2.65	2.64	2.63	2.65
	SD	0.19	0.17	0.15	0.12	0.13

The pre test, post test, first, second and third cessation mean values of experimental and control groups on VO_2 Max are graphically represented in the figure – IV.

Figure – IV
Pre Test, Post Test and Three Cessation Mean Values on Vo_2 Max of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on VO_2 Max were statistically analysed by ANCOVA and the results are presented in table 4.17.

Table 4.17
Analysis of Covariance on Vo_2Max of Resistance Training and Control Groups

	Resistance training group	Control Group	S o V	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean SD	2.65	2.66	B	0.001	1	0.001	0.014
	0.17	0.19	W	0.99	28	0.036	
Post test Mean SD	3.16	2.65	B	1.95	1	1.95	59.54*
	0.18	0.17	W	0.91	28	0.03	
Adjusted Post test Mean	3.16	2.65	B	1.94	1	1.94	57.55*
			W	1.91	27	0.034	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.17 shows that the pre-test mean and standard deviation on VO_2Max of resistance training and control groups are 2.65 $\pm$ 0.17 and 2.66 $\pm$ 0.19 respectively. The obtained 'F' ratio value of 0.014 for pre test means on VO_2 Max of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on VO_2 Max of resistance training and control groups are 3.16 $\pm$ 0.18 and 2.65 $\pm$ 0.17 respectively. The obtained 'F' ratio value of 59.54 for post test means on VO_2 Max of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on VO_2 Max of resistance training and control groups are 3.16 and 2.65 respectively. The obtained 'F' ratio value of 57.55 for adjusted post test mean on VO_2 Max of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the VO_2 Max of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on VO_2 Max have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.18.

Table 4.18
Two Factor Anova on Vo_2 Max of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	0.650	1	0.650	25.79*
Group Error	0.706	28	0.025	
B factor (Tests)	0.71	3	0.23	15.60*
AB factor (Interaction) (Groups and Tests)	0.628	3	0.209	13.78*
Error	1.27	84	0.015	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table 4.18 shows that the obtained 'F' ratio for factor A (Groups) is 25.79 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on VO_2 Max.

Table 4.18 also shows that the obtained 'F' ratio for factor B (Different stages of tests) is 15.60 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that VO_2 Max differs significantly among different stages of testing irrespectively of groups.

Table 4.18 also shows that the obtained 'F' ratio value of Interaction A x B (Groups x Different Tests) is 13.78 which is greater than the table value of

2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study shows that significant differences exist between groups at each test and also between tests for each group on VO_2 Max.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on VO_2 Max. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.19.

Table – 4.19
The Simple Effect Scores of Groups (Rows) at Five Different Stages of Tests (Columns) on Vo_2 Max

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	1.95	1	1.95	130.00*
Groups at First Cessation	0.794	1	0.794	52.93*
Groups at Second Cessation	0.329	1	0.329	21.93*
Groups at Third Cessation	0.115	1	0.115	7.66*
Tests and Group I	1.33	3	0.44	29.33*
Tests and Group II	0.007	3	0.002	0.13
Error	1.27	84	0.015	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table 4.19 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 130.00, 52.93, 21.93 and 7.66 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that significant difference exists between the paired means of groups at post test, first cessation, second cessation and third cessation on VO_2 Max.

Table 4.19 also shows that 'F' values obtained for tests and group-I is 29.33 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 0.13 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. The result of the study indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on VO_2 Max.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.20.

Table – 4.20
Scheffe's Test for the Differences among Paired Means of Resistance Training Group with Different Tests on Vo_2 Max

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
3.16	2.96			0.20*	0.091
3.16		2.84		0.32*	0.091
3.16			2.77	0.39*	0.091
	2.96	2.84		0.12*	0.091
	2.96		2.77	0.19*	0.091
		2.84	2.77	0.07	0.091

**Significant at .05 level of confidence*

Table 4.20 shows that the mean differences between post test and first cessation post test and second cessation, post test and third cessation, first and second cessation, first cessation and third cessation of resistance training group are 0.20, 0.32, 0.39, 0.12 and 0.19 respectively, which are higher than the

confidence interval value 0.091. However the mean difference between second cessation and third cessation is 0.07 respectively on VO_2 Max which are lower than the confidence interval value of 0.091 at 0.05 level of confidence.

Hence it was concluded that the increased VO_2 Max performance of the participants were sustained only for 10 days during determining period, there after it was started decline towards the base line.

4.6: Analysis of Percent Body Fat

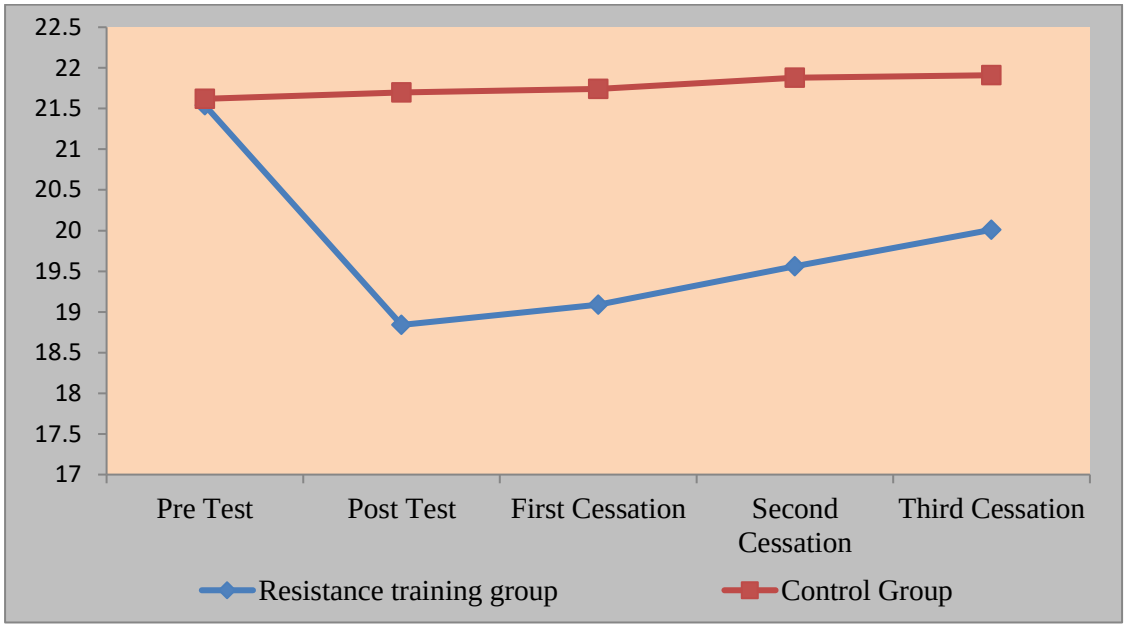
The mean and standard deviation values on percent body fat of resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.21.

Table – 4.21
The Pre, Post Test And Three Cessations Mean And Standard Deviation On Percent Body Fat Of Resistance Training And Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	21.54	18.84	19.09	19.56	20.01
	SD	0.56	0.45	0.41	0.35	0.39
Control Group	Mean	21.62	21.70	21.74	21.88	21.91
	SD	0.40	0.41	0.38	0.50	0.52

The pre test, post test, first, second and third cessation mean values of experimental and control groups on percent body fat are graphically represented in the figure – V.

Figure – V
Pre Test, Post Test and Three Cessation Mean Values on Percent Body Fat of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on percent body fat were statistically analysed by ANCOVA and the results are presented in table 4.22.

Table 4.22
Analysis of Covariance on Percent Body Fat of Resistance Training and Control Groups

	Resistance training group	Control Group	S o V	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean	21.54	21.62	B	0.044	1	0.044	0.18
SD	0.56	0.40	W	6.79	28	0.24	
Post test Mean	18.84	21.70	B	61.34	1	61.34	323.12*
SD	0.45	0.41	W	5.31	28	0.19	
Adjusted Post test Mean	18.84	21.69	B	60.78	1	60.78	309.73*
			W	5.29	27	0.19	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.22 shows that the pre-test mean and standard deviation on percent body fat of resistance training and control groups are 21.54 $\pm$ 0.56 and 21.62 $\pm$ 0.40 respectively. The obtained 'F' ratio value of 0.18 for pre test means on percent body fat of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on percent body fat of resistance training and control groups are 18.84 $\pm$ 0.45 and 21.70 $\pm$ 0.41 respectively. The obtained 'F' ratio value of 323.12 for post test means on percent body fat of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on percent body fat of resistance training and control groups are 18.84 and 21.69 respectively. The obtained 'F' ratio value of 309.73 for adjusted post test mean on percent body fat of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the percent body fat of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on percent body fat have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.23.

Table 4.23
Two Factor ANOVA on Percent Body Fat of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	8.47	1	8.47	70.03*
Group Error	3.38	28	0.12	
B factor (Tests)	8.60	3	2.86	20.86*
AB factor (Interaction) (Groups and Tests)	3.90	3	1.30	9.46*
Error	11.54	84	0.13	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table 4.23 shows that the obtained 'F' ratio for factor A (Groups) is 70.03 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on percent body fat.

Table 4.23 also shows that the obtained 'F' ratio for factor B (Different stages of tests) is 20.86 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that percent body fat differs significantly among different stages of testing irrespectively of groups.

Table 4.23 also shows that the obtained 'F' ratio value of Interaction A x B (Groups x Different Tests) is 9.46 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of

confidence. The result of the study shows that significant differences exist between groups at each test and also between tests for each group on percent body fat.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on percent body fat. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.24.

Table – 4.24
The Simple Effect Scores of Groups (Rows) at Five Different Stages of Tests (Columns) on Percent Body Fat

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	61.34	1	61.34	471.84*
Groups at First Cessation	52.80	1	52.80	406.15*
Groups at Second Cessation	40.36	1	40.36	310.46*
Groups at Third Cessation	27.26	1	27.26	209.69*
Tests and Group I	12.01	3	4.01	30.84*
Tests and Group II	0.49	3	0.21	1.61
Error	11.54	84	0.13	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table 4.24 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 471.84, 406.15, 310.46 and 209.69 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that significant difference exists between the paired means of groups at post test, first cessation, second cessation and third cessation on percent body fat.

Table 4.24 also shows that 'F' values obtained for tests and group-I is 30.84 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 1.61 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. The result of the study indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on percent body fat.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.25.

Table – 4.25
Scheffe's Test for the Differences among Paired Means of Resistance Training Group with Different Tests on Percent Body Fat

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
18.84	19.09			0.25	0.26
18.84		19.56		0.72*	0.26
18.84			20.01	1.17*	0.26
	19.09	19.56		0.47*	0.26
	19.09		20.01	0.92*	0.26
		19.56	20.01	0.45*	0.26

**Significant at .05 level of confidence*

Table 4.25 shows that the mean differences between post test and second cessation, post test and third cessation, first and second cessation, first cessation and third cessation, second cessation and third cessation of resistance training group are 0.72, 1.17, 0.47, 0.92 and 0.45 respectively, which are higher

than the confidence interval value 0.26. However the mean difference between post test and first cessation is 0.25 respectively on percent body fat which are lower than the confidence interval value of 0.26 at 0.05 level of confidence.

Hence it was concluded that the increased percent body fat performance of the participants were sustained only for 10 days during determining period, there after it was started incline towards the base line.

4.7: Analysis of Body Mass Index

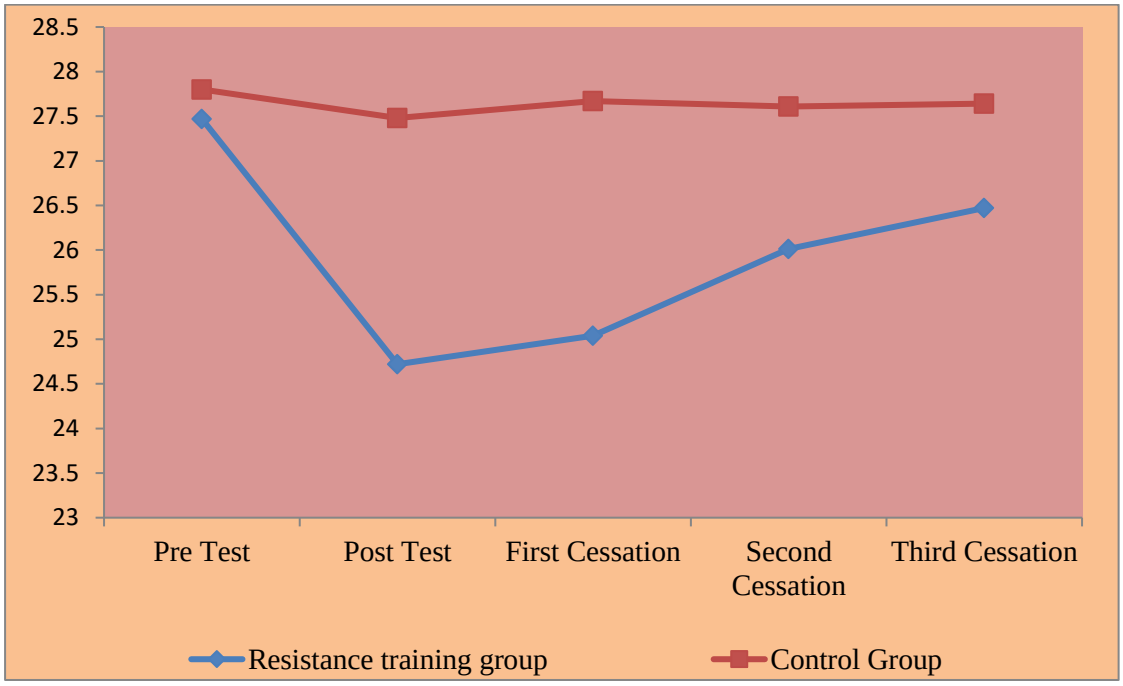
The mean and standard deviation values on body mass index of resistance training and control groups at five different stages of tests have been analyzed and presented in table-4.26.

Table – 4.26
The Pre, Post Test and Three Cessations Mean and Standard Deviation on Body Mass Index of Resistance Training and Control Groups

Groups		Pre Test	Post Test	First Cessation	Second Cessation	Third Cessation
Resistance training group	Mean	27.47	24.72	25.04	26.01	26.47
	SD	1.80	1.93	1.96	1.95	1.93
Control Group	Mean	27.80	27.48	27.67	27.61	27.64
	SD	1.67	1.68	1.76	1.71	1.74

The pre test, post test, first, second and third cessation mean values of experimental and control groups on body mass index are graphically represented in the figure – VI.

Figure – VI
Pre Test, Post Test and Three Cessation Mean Values on Body Mass Index of Resistance Training and Control Groups



The pre and post test data collected from the resistance training and control groups on body mass index were statistically analysed by ANCOVA and the results are presented in table 4.27.

Table 4.27
Analysis of Covariance on Body Mass Index of Resistance Training and Control Groups

	Resistance training group	Control Group	S o V	Sum of Squares	df	Mean squares	Obtained 'F' ratio
Pre test Mean	27.47	27.80	B	0.83	1	0.83	0.27
SD	1.80	1.67	W	84.71	28	3.02	
Post test Mean	24.72	27.48	B	57.13	1	57.13	17.31*
SD	1.93	1.68	W	92.36	28	3.29	
Adjusted Post test Mean	24.85	27.34	B	45.83	1	45.83	35.99*
			W	34.38	27	1.27	

(The required table value for significance at 0.05 level of confidence with degrees of freedom 1 & 28 and 1 & 27 are 4.20 and 4.21 respectively)
**Significant at .05 level of confidence*

Table-4.27 shows that the pre-test mean and standard deviation on body mass index of resistance training and control groups are 27.47 ± 1.80 and 27.80 ± 1.67 respectively. The obtained 'F' ratio value of 0.27 for pre test means on body mass index of experimental and control groups was less than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The post-test mean and standard deviation on body mass index of resistance training and control groups are 24.72 ± 1.93 and 27.48 ± 1.68 respectively. The obtained 'F' ratio value of 17.31 for post test means on body mass index of experimental and control groups was greater than the required table value of 4.20 for the degrees of freedom 1 and 28 at 0.05 level of confidence.

The adjusted post-test mean on body mass index of resistance training and control groups are 24.85 and 27.34 respectively. The obtained 'F' ratio value of 35.99 for adjusted post test mean on body mass index of experimental and control groups was greater than the required table value of 4.21 for the degrees of freedom 1 and 27 at 0.05 level of confidence. Hence it was concluded that due to the effect of twelve weeks of resistance training the body mass index of the subjects was significantly improved.

In order to find out the detraining impact, the data collected from the two groups during post test and three cessation periods on body mass index have been analyzed by two ways factorial ANOVA (2x4) with repeated measures on last factor and the obtained results are presented in table 4.28.

Table 4.28
Two Factor ANOVA on Body Mass Index of Groups at Five Different Stages of Tests

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
A factor (Groups)	14.69	1	14.69	156.39*
Group Error	2.63	28	0.094	
B factor (Tests)	15.09	3	5.03	25.15*
AB factor (Interaction) (Groups and Tests)	10.90	3	3.63	18.15*
Error	16.85	84	0.20	

(Table values required for significance at 0.05 level with df 1 and 28, 3 and 84 are 4.20 and 2.72 respectively.)

Table 4.28 shows that the obtained 'F' ratio for factor A (Groups) is 156.39 which is greater than the table value of 4.20 with degrees of freedom 1 and 28 required for significance at 0.05 level of confidence. The result of the study indicates that, significant differences exist among experimental and control groups irrespective of different stages of testing on body mass index.

Table 4.28 also shows that the obtained 'F' ratio for factor B (Different stages of tests) is 25.15 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that body mass index differs significantly among different stages of testing irrespectively of groups.

Table 4.28 also shows that the obtained 'F' ratio value of Interaction A x B (Groups x Different Tests) is 18.15 which is greater than the table value of 2.72 with degrees of freedom 3 and 84 required for significance at 0.05 level of

confidence. The result of the study shows that significant differences exist between groups at each test and also between tests for each group on body mass index.

The results of the study indicate that significant differences exist in the interaction effect between rows (groups) and columns (tests) on body mass index. Since the interaction effect is significant, the simple effect test has been applied as follow up test and they are presented in table 4.29.

Table – 4.29
The Simple Effect Scores of Groups (Rows) at Five Different Stages of Tests (Columns) on Body Mass Index

Source of Variance	Sum of Squares	df	Mean Squares	Obtained "F" ratio
Groups at Post test	57.13	1	57.13	285.65*
Groups at First Cessation	37.18	1	37.18	185.90*
Groups at Second Cessation	19.36	1	19.36	96.80*
Groups at Third Cessation	10.32	1	10.32	51.60*
Tests and Group I	25.66	3	3.80	19.00*
Tests and Group II	0.33	3	0.11	0.55
Error	16.85	84	0.20	

(Table values required for significance at .05 levels with df 1 and 84, & 3 and 84 are 3.96 and 2.72 respectively.)

Table 4.29 shows that the obtained 'F' ratio values for groups at post test, first, second and third cessation are 285.65, 185.90, 96.80 and 51.60 respectively, which are higher than the table value of 3.96 with degrees of freedom 1 and 84 required for significance at 0.05 level of confidence. The result of the study indicates that significant difference exists between the paired means of groups at post test, first cessation, second cessation and third cessation on body mass index.

Table 4.29 also shows that 'F' values obtained for tests and group-I is 19.00 which is greater than the table value of 2.72 with the degrees of freedom 3 and 84 whereas, for tests and group-II is 0.55 which is lower than the table value of 2.72 with the degrees of freedom 3 and 84 required for significant at 0.05 level of confidence. The result of the study indicates that significant difference exists between various tests of resistance training group, however no significant difference exists between various tests of control group on body mass index.

Since, the obtained 'F' ratio value in the simple effect is found to be significant, the Scheffe'S test is applied as post hoc test to find out the paired mean difference, and it is presented in table 4.30.

Table – 4.30
Scheffe's Test for the Differences among Paired Means of Resistance Training Group with Different Tests on Body Mass Index

Post test	First cessation	Second cessation	Third cessation	Mean difference	Confidence interval
24.72	25.04			0.32	0.33
24.72		26.01		1.29*	0.33
24.72			26.47	1.75*	0.33
	25.04	26.01		0.97*	0.33
	25.04		26.47	1.43*	0.33
		26.01	26.47	0.46*	0.33

**Significant at .05 level of confidence*

Table 4.30 shows that the mean differences between post test and second cessation, post test and third cessation, first and second cessation, first cessation and third cessation, second cessation and third cessation of resistance training group are 1.29, 1.75, 0.97, 1.43 and 0.46 respectively, which are higher

than the confidence interval value 0.26. However the mean difference between post test and first cessation is 0.32 respectively on body mass index which are lower than the confidence interval value of 0.26 at 0.05 level of confidence.

Hence it was concluded that the increased body mass index performance of the participants were sustained only for 10 days during determining period, there after it was started incline towards the base line.

4.8: Discussion on Findings

The result of the study indicates that resistance training improved muscular strength, explosive power, maximum oxygen consumption and decreased resting heart rate, body mass index, percent body fat, to a significant level. However, during the detraining period the improved performance was started declining towards the baseline.

4.8.1: Training and Detraining Responses on Physical Fitness Components

The result of the study indicates that the muscular strength and explosive power of the experimental group improved significantly by underwent the twelve weeks of resistance training programme. The above findings can be substantiated by observations made by following renowned experts. It is well known that resistance training increases muscle mass and strength. These findings agree with those of DeLorme (1945) who reported that a small number of repetitions with high resistance produced strength. Alcaraz et al., (2008) found that heavy-resistance circuit training may be an effective training strategy for the promotion of both strength and cardiovascular adaptations. Coutts et al., (2004) observed that 12 weeks of direct supervision

of resistance training in young athletes results in greater training adherence and increased muscular strength, power, and running speed than unsupervised training. Also consistent with previous studies Mazzetti et al., (2000) found greater maximal strength, power, and muscular endurance gain following 12 wk of periodized heavy-resistance training.

Similarly, Goto (2002) suggested that low intensity strength exercise improves muscular strength more than traditional strength training. LeMura et al., (2002) found that 16 weeks of various modes of resistance training increased upper and lower body strength. Starkey (1996) determined the effects of different volumes of high-intensity resistance training on isometric torque and muscle thickness; found that both groups improved muscular strength torque similarly at most angles. Dorgo et al., (2009), found significant improvements in muscular strength and muscular endurance of the manual resistance and weight resistance training groups. The increases of 1 RM leg press and in 1 RM bench press in the resistance and concurrent training groups are also similar to the magnitude of change reported by earlier investigators (Hennessy & Watson, 1994; Kraemer et al., 1995; McCarthy et al., 1995).

The results of the study also indicated that the improved muscular strength and explosive power of resistance training group decreased significantly during detraining period. But the significant decrease started after the second cessation toward the base line. This finding is supported by Mikel et al., (2007) that 4 weeks of detraining subsequent to a 16-week period of periodized heavy and explosive resistance training results in significant

decreases in bench press 1RM, parallel squat 1RM, and muscle power output of the upper and lower body musculature. Hakkinen et al., (1985) study have shown that training cessation during periods of inactivity ranging from 4 to 12 weeks led to pronounced declines (7–12%) in strength performance. Hakkinen and Komi (1983) reported a 10% decrease in 1RM squat after 4 weeks of training cessation. Hakkinen et al., (1981) observed 11–12% decreases in 1RM squat and leg extension force after 8 weeks of training cessation. Vakizadeh et al., (2012) results showed significantly reduce 1RM in movement bench press and leg press in the experimental groups after 8 weeks detraining. Hence, it is suggested that to prevent loses in improved muscular strength and power performances the athletes and players should not go for detraining not more than 20 days.

4.8.2: Training and Detraining Responses on Physiological Parameters

The result of the study indicates that twelve weeks of resistance training programme significantly altered the resting heart rate and Vo_2max of the subjects. These results are conformity with the following findings. Pulse rate is acutely elevated immediately following a work bout and affected by the amount of resistance, the number of repetitions and the muscle mass involved in the contraction (Fleck, 1988). Interestingly, in terms of chronic adaptations, there appears to be a reduction in pulse rate from resistance training, which is considered beneficial (Stone et al., 1991).

Senthil et al., (2011) findings indicated that the effects of concurrent strength and endurance training significantly reduced resting pulse rate when

compared with control group. Davis et al., (2008) evaluated the effects of concurrent strength and aerobic endurance training and observed that serial concurrent exercise reduced resting heart rate. Wood et al., (2001) conducted a study on concurrent cardiovascular and resistance training in healthy older adults, their result revealed lower resting heart rate. Hickson et al., (1988) suggested that strength training is beneficial to endurance performance in non-athletes.

According to the NSCA, including strength training in an endurance training program can improve the ability of the heart, lungs and circulatory system to perform under conditions of high pressure and force production (NSCA, 2000). Marcinik et al., (1991) stated that time to exhaustion in a cycle ergometer test and lactate threshold can be increased without any change in VO_2 max. Miller and Morehouse (1971) state that repeated and continuous physical exercises may produce extensive change in the respiratory system, the increased stretching of the lung tissue can accommodate more air.

The results of the study also indicated that the resting heart rate of resistance training group increased significantly due to the detraining. But the significant increase started after the first cessation toward the base line. However, the improved Vo2max performance of the subjects was started declining toward the base line within 10 days of detraining. Godfrey (2008) found that detraining of endurance-trained athlete's blood volume is reduced by 5-12% within the first two days. This reduction in blood volume is the primary

reason for the observed rapid decline in cardiovascular function. As a direct result there is a decrease in cardiac output (*amount of blood pumped per minute*) and stroke volume (*amount of blood pumped per beat*) with an attendant increase in heart rate. This finding is supported my result of the study. Hence to avoid loses in improved physiological parameters one should not go for detraining not more than 10 days. Even those ten days they can be engaged by light physical activity otherwise they could lose their gained fitness.

4.8.3: Training and Detraining Responses on Body Composition Variables

The results of the study indicates that the percent body fat of resistance training group decreased significantly by underwent the twelve weeks of resistance training programme. These results are conformity with the following findings. Changes in body composition are typically observed after chronic resistance and or aerobic training favouring an increase in fat-free mass and a decrease in the percentage of body fat (Hakkinen et al., 2003; Williams et al., 2002; Knapik, 1997). According to Hakkinen et al., (2003) the strength and endurance training showed significant decreases in the body fat percentage throughout the experimental training period. The fat-free mass increased in groups performing resistance training regardless of endurance training inclusion (Kraemer et al., 2004). The concurrent training group significantly decreased on percent body fat from pre- to mid-training and from pre- to post-training, (Glowacki, 2004).

The result of the study also indicated that the body mass index of experimental group decreased significantly by underwent the twelve weeks of resistance training programme. These results are conformity with the following findings. Sillanpaa et al., (2008) observed that combined strength and endurance training is a greater value than either alone in optimizing body composition or improving physical fitness in older men. Davis et al., (2008) found decline in fat mass and percent body fat of concurrent training group. Hass et al., (2001) documented that concurrent training, resulted in significant reductions in fat mass and percentage body fat.

The results of the study also indicated that the percent body fat of resistance training group increased significantly due to the detraining. But the significant increase started after the first cessation toward the base line. This study result agreement with the findings of Witkowski et al., (2010) reported that the percentage of body fat was significantly greater after 10 days of detraining. Ormsbee & Arciero (2012) suggested that detraining after a competitive collegiate swim season adversely affects body composition, fitness, and metabolism. Hence, to control the percent body fat one should not go for detraining more than 10 days. Even those ten days can be engaged by light physical activity otherwise they could lose their fitness and regain loosed body fat.

The results of the study also indicated that the body mass index of resistance training group increased significantly due to the detraining. But the significant increase started after the first cessation toward the base line. Hence,

to maintain the body mass index one should not go for detraining more than 10 days. Even those ten days they could be engaged by light physical activity otherwise they could regain the body mass index. The finding accord with the findings of Paul and Thompson (2006) that after (cessation) men quit running, their weight, BMI, and waist and chest circumferences significantly increased in proportion to the change in running distance.

Factors such as initial fitness levels of the subjects, duration of training, training intensity, and the resistance training used could account for the larger gains seen in motor fitness components and larger decrease in body composition and physiological parameters.

4.9: Discussion on Hypotheses

In the first hypothesis of the researcher it was stated that there would be significant changes on selected physical fitness components (*muscular strength and explosive power*), physiological parameters (*resting heart rate and* Vo_2max) and body composition (*percent body fat and body mass index*) variables due to resistance training. The result of this study revealed that as a result of resistance training the muscular strength, explosive power, resting heart rate, Vo_2max, body mass index and percent body fat of the kabaddi players has significantly altered. Hence the researcher's first hypothesis was proved positively.

In the second hypothesis it was stated that the changes on selected physical fitness, physiological parameters and body composition as a result of resistance training would be altered significantly due to the impact of cessation

of training. The result of the detraining shows that there was a significant decrease on muscular strength, explosive power, resting heart rate, Vo_2max, body mass index and percent body fat of the kabaddi players due to the impact of cessation of training. Hence the researcher's second hypothesis was also accepted.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1: Summary

Performance can be increased or improved to a great extent only by causing biological adaptation and this is possible only through systematic and scientific training. Numerous training procedures are in practice to improve motor fitness ability at various levels. Training is a systematic athletic activity of long duration, progressively and individually graded aiming at modeling the human physiology and functions to meet demanding tasks. Though many methods prevail to develop physical, physiological and body composition factors, the role of resistance training is an undisputed one. Resistance training is now a popular activity utilized by both men and women of all ages as an attempt to improve physical condition.

Successful sports performance relies on a number of physical, physiological and body composition factors. Perhaps one of the most important factors in this atmosphere of success relates directly to the type and amount of training performed by the athlete. Therefore, the researchers have continued to explore the most effective means of training for sports and games. The effects of different methods of sports training on physical fitness, body composition and physiological parameters are a useful research objectives and it has been the attention of the present investigator. The present scientific study is one of the efforts to explore and suggest a best scientific method for the development of physical, physiological and body composition factors..

The purpose of the study was to find out the effect of resistance training and detraining on physical fitness, physiological parameters and body composition variables. To achieve the purpose of this study, thirty male inter-collegiate kabaddi players volunteered to participate in the study. The selected participants were studying in various arts and science colleges affiliated to Manonmanium Sundaranar University, from Kanyakumari District, India during the academic year 2016-2017. Their age ranged from 18 years to 22 years. They were randomly divided into two groups and each group consisted of fifteen participants. Group – I performed resistance training and group – II acted as control who did not participate in any specific training programmes.

The subjects were tested on the following variables such as, muscular strength, explosive power, resting heart rate, Vo_2 max, percent body fat and body mass index. The test conducted for two groups prior to and post experimentation and detraining (three cessation) once in ten days. The selected dependent variable muscular strength was measured by 1 RM bench press, explosive power was measured by standing broad jump, resting heart rate was assessed by digital blood pressure monitor, Vo_2 max was assessed by 1 mile run test, percent body fat was measured by skin fold calibre, body mass index was calculated by weight/height meter^2.

The data collected from the two groups prior to and post experimentation were statistically analyzed by applying the analysis of covariance (ANCOVA). The data collected from the two groups on prior and post experimentation and detraining (three cessation) were statistically

analysed by using two way (2 x 4) factorial ANOVA with last factor repeated measures. If the obtained 'F' ratio for interaction effect was found to be significant, the simple effect test was used as a follow up test. Since, two groups and four different stages of test were compared, when the obtained 'F' ratio value in the simple effect test was significant the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases statistical significance was fixed at .05 levels.

5.2: Conclusions

From the statistical analysis of the data, the following conclusions were drawn.

5.2.1: Physical Fitness Components

1. As a result of resistance training the selected physical fitness components namely muscular strength and explosive power of the kabaddi players have significantly improved.
2. During detraining period no significant deterioration on muscular strength performance was found up to ten days thereafter it was started declining towards the baseline. However, explosive power of the kabaddi players have significantly reduced only after 20 days of detraining period.

5.2.2: Physiological Parameters

1. Due to the effect of resistance training the selected physiological parameters such as resting heart rate and maximum oxygen consumption have significantly changed.

2. During the detraining period no significant changes on resting heart rate was found up to ten days thereafter it was started increasing towards the baseline. However, maximum oxygen consumption of the kabaddi players has significantly reduced within 10 days of detraining period.

5.2.3: Body Composition Variables

1. Due to twelve weeks of resistance training the selected body composition variables percent body fat and body mass index have significantly decreased.
2. During detraining period no significant changes on percent body fat and body mass index was found up to ten days thereafter it was started increasing towards the baseline.

5.3; Recommendations

1. Based on the findings of the study it is recommended that the coaches, trainers and physical educators may incorporate resistance training to alter physical, physiological and body composition factors..
2. It is also suggested that the duration of the detraining period should not exceed 10 days, in order to avoid deterioration of performance.
3. Similar study may be conducted to know the changes on bio-chemical parameters and how long it can be sustained after the cessation of training and the rate of decrease.
4. Studies may be attempted on athletes and players of different levels of sports excellence to know the difference in the influence of resistance training and detraining impact.

5. Similar study may be attempted on female subjects.
6. Studies may be conducted with retraining programme.
7. Further studies may be conducted by extending the duration of the training and detraining period.
8. A similar training protocol with strict dietary control may also be an option for future research.

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Appendix-I

CONSENT FORM FOR THE PROPOSED RESEARCH STUDY

Name:

Course:

Mrs**. P. Muthukumar**, Ph.D., scholar in the Department of Physical Education, Manonmanium Sundaranar University has requested my participation in a research study at this institution. The title of the research is "Effect of Resistance Training and Detraining Impact on Selected Physical, Physiological and Body Composition Parameters of Kabaddi Players".

I have informed that the purpose of the research is to identify the effects of resistance training and detraining impact. My participation is involved in resistance training three days in a week for twelve weeks. I understand that there are possible benefits due to participation in this research. I have been advised that the research in which I will be participating does not involve more than minimal risks. I have been informed that I will not be compensated for my participation.

I have read the above information, the nature; demands, risks and benefits of the research have been explained to me. I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty, or loss of benefit to myself. In signing this consent form, I am not to waving any legal commends raised or remedies. A copy of the consent form is given to me.

Date: Participant's Signature

EFFECT OF RESISTANCE TRAINING AND DE-TRAINING ON SELECTED PHYSICAL FITNESS PHYSIOLOGICAL AND BODY COMPOSITION PARAMETERS OF INTER COLLEGIATE KABADDI PLAYERS

A THESIS

Submitted by

P. MUTHUKUMAR

Reg.No : 5785

PHYSICAL EDUCATION

in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

MANONMANIAM SUNDARANAR UNIVERSITY

TIRUNELVELI - 627 012

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